VOLUME XXI OCTOBER, 1938 NUMBER 10

# JOURNAL OF DAIRY SCIENCE

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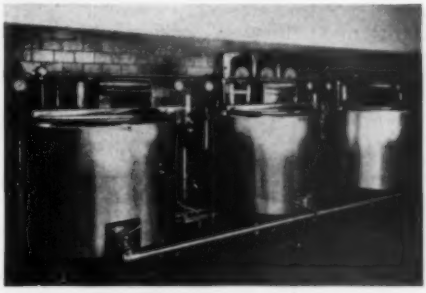

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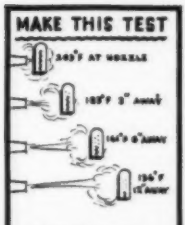


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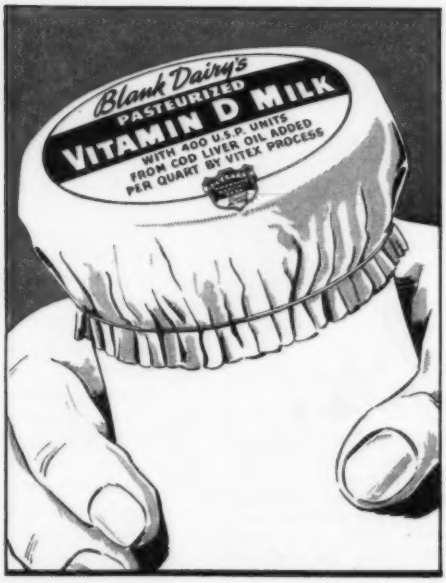


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VOLUME XXI OCTOBER, 1938 NUMBER 10

# RIBOFLAVIN CONTENT OF MILK COLLECTED IN DIFFERENT MONTHS AND CORRELATED WITH OTHER CONSTITUENTS OF THE MILK[1]

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Interest in variations of the riboflavin content of milk is a natural consequence of previous indications that d-ribose may be isolated from whey (10). The availability of a rapid method for the determination of riboflavin in milk (13) offers opportunity for extensive studies of the amount of this substance in milk. Biological determinations at this station (7) have shown colostrum to be richer in flavin than milk produced later in lactation. Such determinations have also suggested that the amounts of riboflavin in samples from groups of different breeds on widely different rations vary within a comparatively narrow range. The purpose of this study was to apply the rapid method of riboflavin determination to samples of normal milk collected at intervals from individual cows of different breeds on different rations; and to compare these values with the seasons and the cows involved; and with the concentrations of various other constituents in the milk.

## PROCEDURE

Samples were procured from each milking of each cow in the station herd on 3 successive days in March, April, May, and July.[2]

The animals used included 4 breeds. A group of young Holsteins on a special ration which had never included pasture, and a group including all breeds which for two periods of six weeks each was fed a ration low in carotene, were also studied. The regular ration included Atlas sorgo silage, alfalfa hay, and a grain mixture of yellow corn, bran, and cotton seed meal. The ration for the experimental Holstein group differed in that white corn was used in the grain mixture and that prairie hay replaced the alfalfa, or for some cows, both the alfalfa and silage. During the time the flavin tests were made, the low carotene ration included wheat straw, cotton seed meal

[1] Contribution No. 227, Department of Chemistry, and No. 78, Department of Food Economics and Nutrition.

[2] The samples were supplied by Professor H. W. Cave of the Department of Dairy Husbandry and were used for several projects in which the Departments of Chemistry and Dairy Husbandry were cooperating.

and molasses. Earlier in the year a grain mixture of yellow corn and bran had been fed the more heavily producing cows of this group. Shortly before the May samples were collected, limited amounts of pasture were provided for all cows except the experimental Holsteins. Pasture later became abundant so that all except the experimental Holsteins received a generous pasture supplement before the July samples were collected.

The determinations for flavin (13), vitamin C (14), and phosphatase (6) were made on morning milks only and on the days the samples were collected. The determinations for total solids[3] (1), fat[3] (1-Babcock), fat color (11), lecithin (4), protein chlorine[3] (8), and lactose (1) were made on composites for each cow of each milking of each 3-day period. The value for protein was obtained by subtracting from the total solids, the sum of the measured values for fat and lactose and an assumed value of 0.75 per cent for ash. All fluorimetric readings for flavin were made jointly by 2 or sometimes 3 observers. The microscopic tests[4] for leucocytes, and for mastitis streptococci, and other forms of bacteria were made on samples of fore milk from small groups of cows at intervals of 2 to 4 weeks. The method of calculating mastitis scores from these tests is described elsewhere (12). The results of these microscopic tests were interpolated to the times at which chemical analyses were made. Comparisons[5] of flavin with breeds, seasons, mastitis, and constituents measured on 3-day composite samples were based on 3-day average values for flavin. Comparisons with constituents measured daily were on the basis of daily values.

## RESULTS

The relations of flavin to breeds, stages of lactation, and seasons are shown in tables 1 to 3 respectively. The flavin content of milk from none of the straw fed cows appeared unusual for the breed concerned, or in relation to later values on the same cow. Values for these milks were, therefore, included with the milk from normally fed cows. The average flavin content of milk increased significantly from Ayrshires to Holsteins, from Holsteins to Guernseys, and from Guernseys to Jerseys. (See table 1.) While the experimental Holsteins produced milk with slightly more flavin than the regular Holsteins, this difference is probably not significant.

The average differences in flavin content of milk samples collected from any one breed of cows, either ½ to 5 months, or 5 to 10 months after the cows

[3] These determinations were made by Mr. W. J. Caulfield of the Department of Dairy Husbandry.

[4] These tests were made by Dr. A. C. Fay and Mr. V. D. Foltz of the Department of Bacteriology as part of a project in which they were cooperating with the Department of Dairy Husbandry.

[5] The authors acknowledge the assistance of (a) Mr. H. H. Laude of the station staff, and Prof. M. C. Moggie of Kansas State College, (b) Dr. George W. Snedecor of the Statistical Laboratory of Iowa State College in making these comparisons.

TABLE 1

*Flavin content of milk from diffeernt breeds of cows*

| Breed | No. of 3-day periods Mar., Apr., May | Flavin content p. p. m. | S.E. of means |
|---|---|---|---|
| Experimental Holsteins | 41 | 1.43 | .053 |
| Ayrshires | 34 | 1.17 | .036 |
| Regular Holsteins | 45 | 1.37 | .043 |
| Guernseys | 38 | 1.53 | .048 |
| Jerseys | 47 | 1.73 | .042 |

TABLE 2

*Flavin content of milk in relation to stage of lactation by breeds*

| Breed | Cows No. | Tests No. | State of lactation months | Flavin content | |
|---|---|---|---|---|---|
| | | | | Cows p. p. m. | Tests p. p. m. |
| Experimental Holsteins | 9 | 21 | ½ to 5 | 1.24 | 1.45 |
| | 4 | 10 | 5 " 10 | 1.35 | 1.35 |
| Regular Holsteins | 11 | 16 | ½ to 5 | 1.29 | 1.39 |
| | 8 | 20 | 5 " 10 | 1.38 | 1.38 |
| Ayrshires | 8 | 17 | ½ to 5 | 1.16 | 1.16 |
| | 6 | 16 | 5 " 10 | 1.16 | 1.15 |
| Guernseys | 4 | 10 | ½ to 5 | 1.54 | 1.49 |
| | 7 | 23 | 5 " 10 | 1.51 | 1.53 |
| Jerseys | 10 | 12 | ½ to 5 | 1.60 | 1.57 |
| | 11 | 31 | 5 " 10 | 1.58 | 1.78 |

freshened, were so small as to be considered negligible. Averages for each stage of lactation in each group of cows were calculated both on the basis of single tests, and also on the basis of averages for each cow in the stage and group. On either basis the flavin content of milk was higher in the first stage of some groups and in the last stage of others.

Although the mean flavin content of milk increased for all the breeds from May to July (see table 3) it is doubtful whether this increase should be ascribed to the change in rations. If pasture produced the increase, it should have started in May. For Guernseys there was in May an increase of some significance, while the experimental Holsteins were the only herd to show a significant decrease at this time. The changes in the other three breed groups were very small. It might be argued that a longer time was needed for pasture to produce the expected rise in flavin. The July values indicated significant rises for only the Guernseys and experimental Holsteins. The flavin increased much more for the experimental Holsteins that received no pasture, than for any other group except the small herd of Guernseys.

The coefficients of correlation between concentrations of flavin in the

TABLE 3

*Changes in the riboflavin content of milk produced in different months*

| Cows used as sources of milk | Date of collection of samples | Average change in flavin p. p. m. | Critical* ratio of change | Coefficients of correlation |
|---|---|---|---|---|
| 15 Experimental | Mar. and Apr. | −0.23 | 1.51 | +0.18 |
| 11 Holsteins | Apr. " May | −0.12 | 3.6 | +0.85 |
| 9 | May " July | +0.23 | 2.8 | +0.07 |
| 11 Regular | Mar. and Apr. | −0.07 | 1.05 | +0.64 |
| 15 Holsteins | Apr. " May | +0.06 | 0.95 | +0.68 |
| 11 | May " July | +0.02 | 0.17 | +0.57 |
| 9 Ayrshires | Mar. and Apr. | −0.09 | 0.77 | −0.40 |
| 10 | Apr. " May | −0.00 | 0.04 | −0.48 |
| 9 | May " July | +0.04 | 0.51 | −0.35 |
| 12 Guernseys | Mar. and Apr. | −0.07 | 0.39 | −0.03 |
| 12 | Apr. " May | +0.25 | 2.2 | +0.00 |
| 6 | May " July | +0.18 | 4.6 | +0.87 |
| 16 Jerseys | Mar. and Apr. | +0.02 | 0.24 | +0.45 |
| 15 | Apr. " May | +0.05 | 1.00 | +0.49 |
| 10 | May " July | +0.15 | 1.2 | +0.58 |

* Change $\sqrt{\frac{s^2x + s^2y - 2sxsy}{N}}$

See:

G. U. Yule, Introduction to Theory of Statistics Ed. 5 p. 211. Griffth.

G. W. Snedecor, Statistical Methods. p. 132. Collegiate Press, Ames, Ia.

G. E. Garrett, Statistics in Psychology and Education. p. 287. Longmans.

milk of given cows on successive months furnish an important measure of the significance of the changes in average values (14). The large variations in these correlations (see last column of table 3) indicate that the causes of variation were not uniform. The variations of climate and ration, which were uniform for all cows were, therefore, certainly not the only important factors which caused the variations in the flavin content of the milk. The Guernseys and Ayrshire breeds showed more irregular correlations, and less consistent relations of flavin to fat than the other three groups.

The relation of flavin to milk yield was found very variable and a helpful discussion of this relation must await further study. Relations of the flavin content of milk to the concentrations of 12 other constituents in the milk are shown in table 4.

The fat is the only one of these constituents for which there was anywhere near a consistent, significant relation in the total group of comparisons made. Effects of season, age of cow, stage of lactation, etc., may later be found to have some significant relations. These effects were found to be unimportant for the relation between flavin and fat. Average values of these constituents for each cow are shown in figure I. In each group except Guernseys there appears to have been a significant positive correlation be-

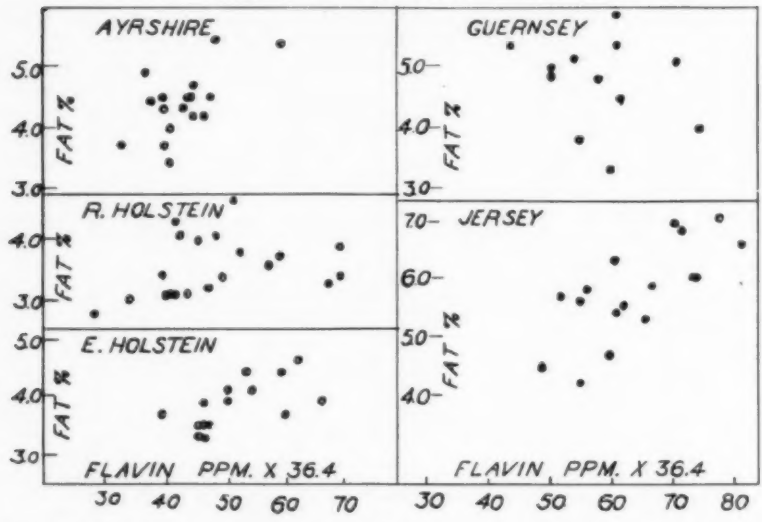
TABLE 4

*Relations of flavin to other constituents of milk in spring and summer months*

| Breed | N | r | CR* | N | r | CR | N | r | CR | N | r | CR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vitamin C per cent of milk 3, 4, 5/37 | | | Loss of C. 72 hrs. at 4° C. 3/37 | | | Carotene per cent of fat 3, 4, 5/37 | | | Lecithin per cent of fat 3/37 | | |
| Experimental Holsteins | 114 | −.025 | .26 | 28 | −.314 | 1.69 | 35 | −.203 | 1.20 | 11 | −.248 | |
| Regular Holsteins | 125 | −.145 | 1.63 | 36 | −.505 | 3.41 | 45 | −.145 | .98 | 11 | −.092 | |
| Ayrshires | 96 | −.064 | .63 | 36 | −.134 | .80 | 33 | −.088 | .50 | 11 | −.018 | |
| Guernseys | 98 | −.063 | .67 | 31 | −.132 | .73 | 38 | −.286 | 1.80 | 13 | −.483 | |
| Jerseys | 136 | −.403 | 5.10 | 46 | −.121 | .82 | 53 | −.160 | 1.68 | 15 | −.166 | |
| | Fat 3, 4, 5, 7/37 | | | Protein 3, 5, 7/37 | | | Lactose 3, 5, 7/37 | | | Phosphatase 3, 4, 5/37 | | |
| Experimental Holsteins | 51 | −.404 | 3.65 | 35 | −.210 | 1.25 | 36 | −.014 | .08 | 103 | −.048 | .49 |
| Regular Holsteins | 59 | −.352 | 2.80 | 41 | −.034 | .22 | 44 | −.016 | .10 | 116 | −.148 | 1.82 |
| Ayrshires | 44 | −.437 | 3.15 | 35 | −.118 | .69 | 37 | −.110 | .67 | 92 | −.206 | 2.02 |
| Guernseys | 40 | −.240 | 1.55 | 31 | −.199 | 1.12 | 32 | −.013 | .07 | 95 | −.354 | 3.65 |
| Jerseys | 57 | −.490 | 4.15 | 38 | −.246 | 1.59 | 38 | −.231 | 1.39 | 127 | −.250 | 2.91 |
| | Leucocytes 3, 4, 5/37 | | | Streptococci 3, 4, 5/37 | | | Odd bacteria 3, 4, 5/37 | | | Chlorine 3, 4, 5, 7/37 | | |
| Experimental Holsteins | 39 | −.220 | 1.38 | 39 | | | 39 | −.161 | 1.00 | 51 | −.060 | |
| Regular Holsteins | 45 | −.242 | 1.63 | 45 | −.328 | 2.20 | 45 | −.230 | 1.55 | 59 | −.160 | |
| Ayrshires | 33 | −.554 | 3.70 | 33 | −.245 | 1.41 | 33 | −.296 | 1.73 | 44 | −.030 | |
| Guernseys | 38 | −.109 | .67 | 38 | −.105 | .64 | 38 | −.090 | .55 | 40 | −.116 | |
| Jerseys | 47 | −.096 | .66 | 47 | −.435 | 3.20 | 47 | −.190 | 1.32 | 58 | −.180 | |

* $CR = \frac{r(N-2)^{\frac{1}{2}}}{(1-r^2)^{\frac{1}{2}}}$. George W. Snedecor, Statistical Methods 1937 Edition, Page 125, Collegiate Press Inc., Ames, Iowa.

FIGURE 1 FLAVIN AND FAT IN MILK FROM COWS OF DIFFERENT BREEDS




tween flavin and fat content. The apparent negative relation for Guernseys may be due to the small number of cows tested. If real, it would be a more serious exception to the relation in other groups if these Guernseys were not also exceptional in the relations of lecithin, and phosphatase to flavin. The authors have at present no explanation for this possible unusual behavior of the Guernsey group, but the distinctive relation of flavin to three different constituents, indicates considerable probability that either Guernseys as a breed, or this particular group, were unusual.

That the fat, which is in an entirely different phase of the milk from the flavin, was the only constituent to which the flavin was regularly related is indeed surprising. There is, however, evidence that flavin functions in combination with protein (9), and that milk-fat is synthesized from carbohydrates derived from proteins or amino acids (5). If flavin plays a rôle in fat synthesis, it would not be surprising that the disturbance of this rôle among Guernsey cows was associated with unusual relations of flavin to lecithin and phosphatase. Both the flavin and phosphatase values were subject to large daily variations. While some of the variations in fat and lecithin were lost in the use of composite samples, it is generally accepted that fat, at least, is also one of the most variable constituents of milk. The variation of lecithin is less known, but from the values summarized in table 4 and from other values on samples for which flavin was not measured (2, 4), we may expect this variation to be as great as for fat. Little or nothing

is known of the rôle played by either flavin, phosphatase or lecithin in the synthesis of milk fat. They would all be classed among the active or unstable constituents of milk and might therefore be involved in this synthesis.

## SUMMARY

Riboflavin determinations were made on samples of milk collected at intervals from individual normal cows of different breeds and on different rations. The influences of season and individuality on flavin values were considered. The relationship of flavin content to the concentrations of the following constituents in the milk were tested: vitamin C, loss of C on 72 hours storage at 4° C, carotene, lecithin, fat, protein, phosphatase, leucocytes, mastitis streptococci, odd bacteria, lactose, and chlorine.

The average flavin contents in March, April, and May were for Ayrshires 1.17 parts per million, for Holsteins 1.37, for Guernseys 1.53, and for Jerseys 1.73. Milk from cows between 15 days and 10 months after freshening, showed no significant difference in flavin content.

The flavin content of milk was slightly higher in July after the cows had been pastured. The climate and ration were not the only important factors which caused variations in the flavin content of milk.

The fat is the only constituent of milk for which an approach to a significant consistent relation to flavin was found. It is suggested that flavin may have a rôle in the production of milk fat.

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# BOUND WATER AND ITS RELATION TO SOME DAIRY PRODUCTS

## III. THE RELATION OF BOUND WATER TO SOME DAIRY PHENOMENA[1]

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Previous studies have shown that liquid dairy products contain appreciable amounts of bound water (1) and that the bound $\rightleftarrows$ free water equilibrium may be changed by certain treatments (2). Since milk and other dairy products contain a colloidal complex, it was thought desirable to investigate certain dairy phenomena from the standpoint of hydration.

### EXPERIMENTAL METHODS

The samples and methods used were, on the whole, as previously described (1). Although in certain experiments changes in samples and methods were made, these changes will be dealt with under the sections reporting the experimental work.

### POSSIBLE RELATION OF BOUND WATER CONTENT TO THE CREAMING OF MILK

The gravity formation of a maximum cream layer on bottled milk is of considerable importance in the market milk industry, largely because of the layman's method of judging richness. The processor of milk knows in a general way the factors affecting creamline but does not understand exactly why heat treatment is destructive to creamline. It was to supplement the existing knowledge of the creaming of milk that this work was undertaken in the hope that further explanation would be obtained.

The inhibited creaming of heated milk has attracted attention ever since pasteurization was first accepted as a general practice in the milk industry and much has been written in attempting to explain this phenomenon. Rahn (3) showed that the creaming property can be restored after heating by the addition of gelatin or other accelerating colloids. Van Dam and Sirks (4) added to milk such colloids as gelatin, starch, Irish Moss and gum tragacanth and obtained a 15–25 per cent increase in volume of cream, and postulated that fat clumping took place. Babcock and Russell (5) and others found that the presence of fat clumps was essential to creaming.

Palmer and Anderson (6) believed that the plasma colloids were of con-

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siderable importance in the creaming of milks of uniform fat content. They stated that the calcium caseinate was a factor in creaming, and thus it was affected by pasteurization temperatures. The whey colloids, which are greatly hydrated, are effective promotors of cream rising. These investigators state further that "Both exhaustiveness of rise of fat and greater volume of cream are promoted by the truly hydrophilic colloids and depressed by colloids of hydrophobic properties."

Therefore it might be that the effect of heat on creaming centers around the plasma colloids to a certain degree. The conditions and the forces acting at the fat/plasma interface may also be of importance. A truly hydrophilic colloid added to milk gives a quicker cream rise, a larger cream layer of lower fat content, and a plasma of lower fat content. The increase in viscosity of milk by non-colloids like sugar delays creaming (3).

The chief stability factor of a hydrophilic colloid is its degree of hydration. The fat globule membrane is composed chiefly of phospholipids and protein. That the phospholipids are greatly hydrophilic has been previously shown (1). It is also known that the casein of milk owes its stability to charge and hydration. With this information a series of experiments were made to determine the relationship between high heat treatment, bound water content, and the creaming ability of milk.

Three experiments were conducted as follows: (1) Raw whole milk was heated in a water bath to different temperatures and held for various lengths of time. (2) Raw cream was added to skimmilk which had been heated to various temperatures. (3) Raw skimmilk was added to cream which had previously been heated to various temperatures. In each case unheated samples were used as controls and all samples came from the same source. The temperatures used were 143° F. for 30 minutes, 160° F. for 5 minutes, and 180° F. momentarily. After the skimmilk or cream was heated, it was cooled to approximately 80° F. before reconstituting. Samples for creaming were stored at 38° F. in 100 ml. graduated cylinders and examined after 24-hour intervals. The results are expressed as percentage cream volume per one per cent fat.

The results of these experiments are recorded in Tables 1, 2 and 3. Table 1 shows the effect of heat on the creaming ability and bound water content of fresh whole milk. Table 2 shows the effect of heat on the creaming ability and bound water content of whole milk prepared from heated skimmilk to which fresh raw 48 per cent cream was later added. Table 3 shows the effect of heat on the creaming ability and bound water content of whole milk prepared from heated 54 per cent cream to which raw skimmilk was later added.

Pasteurization of whole milk at 143° F. for thirty minutes, if done correctly, has very little effect on the creaming ability of the milk. The bound water reduction was slight when compared to higher heat treatments. At

TABLE 1

*The effect of heat treatment on the creaming ability and bound water content of fresh raw milk*

| Treatment | Hours aged at 40° F. | Per cent solids | Alcohol No. | Viscosity centipoises | Volume cream layer per one per cent fat | Per cent bound water | Per cent decrease in bound water content due to heating |
|---|---|---|---|---|---|---|---|
| 1. Unheated | 24 | 11.92 | 8.1 | 2.204 | 4.23 | 3.75 | ..... |
| 2. Heated to 143° F. for 30 min. | 24 | 12.09 | 9.1 | 2.102 | 4.06 | 3.56 | 5.6 |
| 3. " " 160° F. for 5 " | 24 | 11.94 | 9.3 | 2.041 | 0.77 | 3.06 | 18.4 |
| 4. " " 180° F. for 0 " | 24 | 12.11 | 9.3 | 2.061 | 0.76 | 3.30 | 12.0 |

TABLE 2

*The effect of heat treatment on the creaming ability and bound water content of reconstituted milk (heated skimmilk plus raw cream)*

| Treatment | Hours aged at 40° F. | Per cent solids | Alcohol No. | Viscosity centipoises | Volume cream layer per one per cent fat | Per cent bound water | Per cent decrease in bound water content due to heating |
|---|---|---|---|---|---|---|---|
| 1. Unheated | 24 | 12.43 | 7.6 | 2.122 | 4.11 | 3.41 | ..... |
| 2. Skimmilk heated to 143° F. for 30 min. | 24 | 12.19 | 8.0 | 2.061 | 3.00 | 3.11 | 8.8 |
| 3. Skimmilk heated to 160° F. for 5 min. | 24 | 12.24 | 8.3 | 2.241 | 0.72 | 2.45 | 28.1 |
| 4. Skimmilk heated to 180° F. for 0 min. | 24 | 12.38 | 8.3 | 2.306 | 0.64 | 2.29 | 32.8 |

TABLE 3

*The effect of heat treatment on the creaming ability and bound water content of reconstituted milk (heated cream plus raw skimmilk)*

| Treatment | Hours aged at 40° F. | Per cent solids | Alcohol No. | Viscosity centipoises | Volume cream layer per one per cent fat | Per cent bound water | Per cent decrease in bound water content due to heating |
|---|---|---|---|---|---|---|---|
| 1. Unheated | 24 | 12.71 | 7.5 | 2.163 | 4.00 | 3.38 | ..... |
| 2. Cream heated to 143° F. for 30 min. | 24 | 12.55 | 7.5 | 2.102 | 3.79 | 3.22 | 4.0 |
| 3. Cream heated to 160° F. for 5 min. | 24 | 12.67 | 7.6 | 2.082 | 3.58 | 2.80 | 14.5 |
| 4. Cream heated to 180° F. for 0 min. | 24 | 12.58 | 7.6 | 2.000 | 3.46 | 2.64 | 19.0 |

the higher temperatures there was a more marked reduction in bound water content and the volume of the cream layer was also greatly reduced.

Table 2 shows that the heating of the skimmilk alone and subsequent adding of fresh cream to it to make a normal milk, gives results similar to those obtained when whole milk is heated except that the reduction in the cream layer and bound water content is much greater.

The heating of the cream to high temperatures does not have a marked effect upon the cream layer although the bound water content of the reconstituted milk was noticeably reduced but not as much as when the plasma only was heated. Apparently when the cream is heated there is a reduction in the bound water content of the hydrophilic fat globule membrane of the cream. From these experiments it might be said that the bound water content of milk colloids does not affect greatly the creaming ability of the milk. The greatest reduction in creaming was obtained in the samples containing the greatest reduction in bound water content it is true, but the differences in bound water reduction shown in Tables 1 and 3 do not indicate any relation to creaming ability exhibited in the same samples.

## THE RELATION OF BOUND WATER CONTENT TO THE SPECIFIC GRAVITY OF MILK

Freshly drawn milk invariably shows an increase in specific gravity on standing. This is commonly referred to as Rechnagel's phenomenon. Rechnagel (7) associated this change with an increase in the hydration of the proteins. He did not study skimmilk. Quevenne (8) also thought that changes in protein hydration were concerned. Toyonaga (9) obtained results that show that a change in specific gravity was due to volume changes when the fat solidified and that the change did not occur in skimmilk. Fleischman and Wiegner (10) obtained the density increase when milk was held at 15° C. and confirmed the results of Toyonaga. Fleischman (11) observed that the changes of volume of milk with temperature changes are greater than for water. These changes with temperature are attributed principally to variation in hydration of the proteins.

Davies (3) attributes the increase in density on standing to: (1) changes in the specific gravity of the fat due to cooling and partial solidification; (2) hydration of the proteins; and (3) loss of carbon dioxide. Sharp and Hart (12) state that previous temperature history of the milk influences its specific gravity at 15° C. and that this variation is due to the physical state of the fat.

Rechnagel (7) found that the rise in density is regular, and is more rapid at low than at high temperatures and amounts to 0.001. Richmond (13) found the average change to be 0.0006 with a variation from 0.0003–0.0015 and attributes this largely to the increase in density of the fat on solidification. He further states that the effect does not vary seasonally

but may vary with milk from individual cows or from one sample to another.

Freshly drawn mixed milk was used to note if the change in specific gravity was accompanied by a change in bound water content on standing. The milk was quickly cooled in ice water to 40° F. after processing and several experiments were conducted. The specific gravity was determined with the Westphal balance at 15° C. The milk was divided into four lots and comparisons were made of the following: (1) raw milk, freshly drawn; (2) milk heated to 143° F. for 30 minutes; (3) raw skimmilk; and (4) skimmilk heated to 143° F. for 30 minutes. To eliminate dissolved gases as a factor, lots 2 and 4 were heated, and to eliminate butter fat as a factor, experiments with skimmilk were conducted. Determinations were made on the freshly prepared samples, after holding 8 and 24 hours at 40° F. (Table 4.)

TABLE 4

*The relation of bound water content to the specific gravity of milk*

| Sample | Hours aged at 40° F. | Per cent solids | Viscosity centipoises | Specific gravity (15° C.) | Per cent bound water |
|---|---|---|---|---|---|
| 1. Raw milk | 0 | 13.25 | 2.245 | 1.0314 | 2.79 |
| | 8 | 13.25 | 2.347 | 1.0328 | 2.98 |
| | 24 | 13.25 | 2.387 | 1.0332 | 3.18 |
| 2. Pasteurized milk | 0 | 13.61 | 2.183 | 1.0323 | 2.48 |
| | 8 | 13.61 | 2.285 | 1.0338 | 2.71 |
| | 24 | 13.61 | 2.326 | 1.0340 | 2.71 |
| 3. Raw skimmilk | 0 | 9.44 | 1.775 | 1.0359 | 1.81 |
| | 8 | 9.44 | 1.836 | 1.0366 | 2.05 |
| | 24 | 9.44 | 1.877 | 1.0371 | 2.13 |
| 4. Pasteurized skimmilk | 0 | 9.48 | 1.591 | 1.0358 | 1.41 |
| | 8 | 9.48 | 1.632 | 1.0372 | 1.69 |
| | 24 | 9.48 | 1.694 | 1.0375 | 1.81 |

It will be noted in Table 4 that milk and skimmilk, whether raw or pasteurized, increase in specific gravity and bound water content upon standing at 40° F. The specific gravity of raw milk increased 0.0018, and in the pasteurized milk it increased 0.0017 in 24 hours. When the raw milk was pasteurized the specific gravity increased 0.0009, showing that the dissolved gases or an increase in concentration of solids may play a part in this phenomenon. The difference in specific gravity between the raw and pasteurized skimmilk samples was only 0.0001 when determinations were made on freshly prepared samples.

Results obtained indicate that there is an increase in specific gravity of raw and pasteurized skimmilk on standing which cannot be attributed to either the dissolved gases, or to the solidification of the fat globules since in the skimmilk very little fat is present. The increase was 0.0012 in the raw skimmilk and 0.0017 in the pasteurized skimmilk. The bound water studies indicate that the increase in specific gravity might be attributed to the hydration of the lyophilic colloids.

### THE EFFECT OF AGE AND TREATMENT ON THE BOUND WATER CONTENT OF VACUUM DRUM DRY SKIMMILK

To note whether there were any changes in the bound water content of vacuum drum dry skimmilk on aging, samples were stored in open and closed cardboard containers. To determine the bound water content, reconstituted mixtures were made that contained approximately 24 per cent total solids. The bound water content was determined on these mixtures made from fresh dry skimmilk, dry skimmilk stored four weeks and dry skimmilk stored eight weeks at room temperature. The results of these trials are recorded in Table 5.

TABLE 5

*The effect of age and treatment on the bound water content of vacuum drum dry skimmilk*

| Sample* | Hours aged at 40° F. | Per cent solids | Viscosity centipoises | Alcohol No. | Per cent bound water | Grams bound water per gram of solids |
|---|---|---|---|---|---|---|
| 1 | 0 | 24.09 | 12.641 | 5.6 | 11.22 | 0.465 |
| | 24 | 24.09 | 13.530 | 5.4 | 14.72 | 0.611 |
| 2 | 0 | 24.52 | 11.160 | 5.4 | 9.26 | 0.377 |
| | 24 | 24.52 | 12.345 | 5.4 | 9.89 | 0.403 |
| 3 | 0 | 23.25 | 10.883 | 5.4 | 8.77 | 0.377 |
| | 24 | 23.25 | 11.476 | 5.4 | 8.81 | 0.378 |
| 4 | 0 | 24.95 | 8.770 | 5.5 | 9.30 | 0.372 |
| | 24 | 24.95 | 9.560 | 5.5 | 10.01 | 0.401 |
| 5 | 0 | 24.71 | 8.533 | 5.5 | 7.87 | 0.318 |
| | 24 | 24.71 | 9.402 | 5.5 | 8.87 | 0.358 |

*1. Reconstituted dry skimmilk—fresh.
2. " " " —four weeks old in closed container.
3. " " " —" " " " open "
4. " " " —eight " " " closed "
5. " " " —" " " " open "

It is evident that there is a decrease in the amount of bound water per gram of total solids as the dry skimmilk becomes older. The decrease in bound water content is more marked in the samples of dry skimmilk stored in open containers. No difference in solubility of the dry skimmilk was noticed when these samples were reconstituted. A decrease of viscosity also occurred on storage of the dry skimmilk. The protein stability was not markedly altered by the periods of storage.

### THE EFFECT OF "SUPERHEATING" ON THE BOUND WATER CONTENT OF CONDENSED SKIMMILK

The thickening produced in superheated condensed skimmilk is associated with the coagulation of the calcium caseinate. To observe the effect of superheating on the bound water content, a freshly prepared sample of condensed skimmilk was obtained directly from the vacuum pan. Part of the sample was used as the control and the other part was thickened by heating

to 180° F. for 20 minutes in a water bath. The results obtained may be observed in Table 6.

TABLE 6

*The effect of superheating on the bound water content of condensed skimmilk*

| Sample | Hours aged at 40° F. | Per cent solids | Viscosity centipoises | Per cent acid | Alcohol No. | Per cent bound water | Grams bound water per gram of solids |
|---|---|---|---|---|---|---|---|
| 1. Condensed skimmilk | 0 | 26.27 | 6.459 | 0.58 | 5.0 | 8.09 | 0.307 |
| | 24 | 26.27 | 7.644 | 0.60 | 5.3 | 10.97 | 0.417 |
| 2. Superheated condensed skimmilk | 0 | 26.43 | 21.124 | 0.575 | 5.7 | 8.99 | 0.340 |
| | 24 | 26.43 | 23.525 | 0.595 | 5.8 | 10.57 | 0.399 |

Although a large increase in viscosity is characteristic of superheating, there was little change in the bound water content because of the superheating. Both samples had been previously forewarmed in the hot well at 180° F. Superheating produced a noticeable increase in the stability of the proteins as recorded by the alcohol number. The change in viscosity obtained on superheating is not due to hydration but to coagulation.

### THE EFFECT OF THE INITIAL AGING TEMPERATURE ON THE BOUND WATER CONTENT OF CONCENTRATED MILK PLASMA

The initial aging temperature is known to change some of the properties of dairy products, notably the viscosity of the system. To note if there were any bound water changes, concentrated milk plasma was aged in water baths at 90° F., 70° F., 50° F. and 34° F. and the bound water content then determined.

The results show that more water is bound initially at the higher aging temperature than at the lower temperatures. Therefore the process of imbibition is slower at the lower temperatures.

From these findings, it would seem reasonable to believe that short aging periods at relatively high temperatures would give ice cream mixes characteristics similar to low temperature mixes aged for longer periods. Mueller and Frandsen (14) have shown that about one-fourth of the gelatin content of ice cream mixes could be saved by using an aging temperature of 68° F. for 2 to 4 hours instead of cooling to a low temperature immediately after pasteurization and aging for a longer period as is the custom in ice cream plants.

It was also found by these writers that such ice cream mixes whipped as well as mixes aged at lower temperatures. The results in Table 7 indicate that more water is initially bound at 90° F. than at lower temperatures and this may be responsible for results noted by Mueller and Frandsen.

TABLE 7

*The effect of the initial aging temperature on the bound water content of concentrated milk plasma*

| Sample | Hours aged | Per cent solids | Viscosity centipoises | Per cent acid | Alcohol No. | Per cent bound water | Grams bound water per gram of solids |
|---|---|---|---|---|---|---|---|
| 1. Aged at 90° F. | 4 | 13.71 | 4.859 | 0.28 | 8.4 | 5.52 | 0.403 |
| | 24 | ..... | ..... | ..... | ..... | ..... | ..... |
| 2. Aged at 70° F. | 4 | 13.71 | 4.701 | 0.265 | 8.4 | 4.58 | 0.334 |
| | 24 | 13.71 | 4.859 | 0.260 | 8.4 | 5.38 | 0.392 |
| 3. Aged at 50° F. | 4 | 13.71 | 4.563 | 0.265 | 8.3 | 4.21 | 0.307 |
| | 24 | 13.71 | 4.997 | 0.280 | 8.3 | 5.77 | 0.421 |
| 4. Aged at 34° F. | 4 | 13.71 | 4.405 | 0.260 | 8.2 | 3.92 | 0.286 |
| | 24 | 13.71 | 4.859 | 0.280 | 8.1 | 5.11 | 0.373 |

THE EFFECT OF AGING AT LOW TEMPERATURES ON THE BOUND WATER CONTENT OF FLUID MILK PRODUCTS

In studying the effect of aging on the bound water content, samples were stored at 40° F. for 4 and 24 hours, after which time the determinations were made in duplicate. Approximately 40 minutes elapsed from the time the samples were obtained until the determinations were made on the fresh samples. Determinations were made again after aging for 4 and 24 hours. In the tables previously presented, the effect of aging at 40° F. is plainly seen. In all cases (Tables 4, 5, 6, 7) the samples aged at 40° F. contained more bound water than the fresh sample. Aging of the ice cream mix 12 to 24 hours has been common practice in the ice cream industry. This is done to enhance the whipping ability of the mix in the freezer. Work by Dahle, Keith and McCullough (15), Hening (16) and others have shown that approximately four hours of aging produces whipping results as satisfactory as 24 hours of aging. Viscosity studies show that much of the increase in viscosity takes place in that four-hour period.

That whipping ability might go hand in hand with bound water content is indicated in Table 8. In this table is shown also that in the mixes which were homogenized at various pressures the viscosity increase during aging is greatest in the four-hour period. The bound water content shows the greatest increase in the first four hours of aging. The increase is slight after that period up to 24 hours, and it is apparent (15) that aging for the purpose of increasing bound water content need not be practiced longer than four hours at 40° F.

Sugar and gelatin were purposely omitted from these mixes because of the interference offered in making the bound water determinations.

Homogenization with single pressures reduced the bound water content, but the bound water content was restored and even slightly increased by dual homogenization as noted in mix sample No. 4. In this case fat clump-

TABLE 8

*Relationship between age of an ice cream mix, viscosity and bound water (mixes contained 14.75 per cent fat and 12.15 per cent M.S.N.F.*)*

| Mix No. | Pressure used | Hours aged at 40° F. | Viscosity centipoises | Per cent bound water |
|---|---|---|---|---|
| 1 | 0 | 0 | 7.9 | 5.14 |
| | | 4.0 | 9.12 | 5.56 |
| | | 24.0 | 8.8 | 5.29 |
| 2 | 1500 | 0 | 12.9 | 2.43 |
| | | 4.0 | 14.1 | 3.22 |
| | | 24.0 | 14.7 | 3.79 |
| 3 | 3000 | 0 | 45.3 | 1.96 |
| | | 4.0 | 52.4 | 2.23 |
| | | 24.0 | 53.23 | 3.47 |
| 4 | 3000 and 700 | 0 | 10.5 | 5.65 |
| | | 4.0 | 12.8 | 5.93 |
| | | 24.0 | 12.4 | 6.18 |

* No gelatin or sugar was used in mix.

ing was destroyed while in the other homogenized samples much clumping took place.

Cream and other products show an increase in bound water content on aging. Previous work (1, 2) shows that fresh raw cream increased about 16 per cent in bound water on aging, while pasteurized cream increased approximately 30 per cent. Heavy cream increases more in bound water on aging than does light cream. The substances associated with the fat also increase in bound water content on aging. This shows that they are partially responsible for the increase in the bound water content of dairy products containing butterfat.

### THE RELATION OF BOUND WATER CONTENT TO THE VISCOSITY OF SWEET CREAM

Cream was prepared according to the Hening and Dahlberg method (17) and its viscosity and bound water content compared with raw cream and ordinary pasteurized cream. The method used is as follows: Raw cream is pasteurized at 143° F. for 30 minutes and then cooled to 40° F. or lower. It is then warmed to 84° F. in seven minutes and cooled to 48° F. in 14 minutes. The cream is cooled to 40° F. in a refrigerator.

It was thought that since this method produces such a noticeable increase in viscosity, there may be a corresponding increase in bound water content. Therefore, a number of studies were made on fresh cream and cream after 24 hours of storage at 40° F. (Table 9).

The Hening and Dahlberg method of increasing the viscosity of sweet cream shows an increase in the bound water content over ordinary pasteurized sweet cream held at 40° F. for 24 hours, although less bound water is present than is present in aged raw cream.

Hening and Dahlberg found that the increased viscosity obtained by this

TABLE 9

*The effect of temperature treatment on the bound water content and viscosity of sweet cream*

| Treatment | Hours aged at 40° F. | Per cent solids | Viscosity centipoises | Alcohol No. | Per cent bound water | Grams bound water per gram solids |
|---|---|---|---|---|---|---|
| 1. Unheated | 0 | 40.25 | 24.694 | 5.0 | 5.39 | 0.134 |
| | 24 | 40.25 | 29.796 | 5.2 | 6.26 | 0.156 |
| 2. Heated to 143° F. for 30 min. | 0 | 41.40 | 22.653 | 5.2 | 3.94 | 0.095 |
| | 24 | 41.40 | 25.918 | 5.3 | 5.11 | 0.123 |
| 3. Special temperature treatment | 0 | 41.49 | 20.000 | 5.2 | 4.95 | 0.119 |
| | 24 | 41.49 | 28.751 | 5.4 | 5.64 | 0.136 |

method of treating cream could not be associated with increased clumping of the fat globules. These results were substantiated by the writers. From the data obtained it is shown that the hydrophylic colloids become more hydrated by this temperature treatment, though this is not necessarily offered as an explanation for the viscosity change obtained.

### THE RELATION OF BOUND WATER CONTENT TO VISCOSITY

In this work a study was made of the data presented to show, if possible, the relationship between viscosity and bound water content in dairy products. In viscosity studies we are usually dealing with lyophilic systems, since in general the lyophobic sols exhibit a viscosity which approaches very closely the viscosity of the pure dispersions medium, and which increases only slightly with increasing concentration of dispersed material. In dairy products we are dealing with a heterogeneous system. Nevertheless, changes in bound water content should produce changes in viscosity although the differences may not be well defined.

The viscosity studies in Tables 4, 6, 7, 8 and 9 show that the aging of liquid dairy products at low temperatures usually causes an increase in viscosity and bound water content. It appears in these tables that the greater the amount of solids present, the greater is the increase in viscosity on aging. In many of these instances the increases do not appear very great but when the initial viscosities are taken into consideration they are significant. Undoubtedly the increase in viscosity on aging is due to the increase in bound water content of the lyophilic colloids. These results agree with those of Evenson and Ferris (18) and Dahlberg and Hening (19) who show that aging increases the viscosity of milk and cream.

The pasteurization of milk and cream causes a decrease in the viscosity and the bound water content. The viscosity of milk and cream did not return to the original reading even after aging at low temperatures as can be seen in Tables 1, 2, 3, 4 and 9. Many workers, especially Dahlberg and Hening (19), Evenson and Ferris (18), and Babcock and Russell (20) have

demonstrated that heating of whole milk causes a diminution of the viscosity.

Table 8 shows that homogenization increased the viscosity of ice cream mixes and decreased the bound water content. The greater the pressure of homogenization the more pronounced was the increase in viscosity and decrease in bound water content. It will be noted in mix sample No. 4 of Table 8 that dual homogenization decreased the viscosity and increased the bound water content. Undoubtedly the increase in viscosity in single homogenization is due to the clumping of the fat globules, and to greater fat surface.

### THE RELATION OF BOUND WATER TO PROTEIN STABILITY

The alcohol stability determination is probably the most accurate test used to measure the stability of the proteins in certain dairy products. A relatively high alcohol number is usually associated with greater heat and acid stability, and stability to homogenization and freezing.

Throughout this investigation, where feasible, the alcohol number was determined to note if any correlation between alcohol stability and bound water content was obtained. Some of the more positive results are recorded in Table 10.

TABLE 10

*The relation of bound water content to protein stability in some dairy products*

| Sample | Hours aged at 40° F. | Per cent solids | Alcohol No. | Per cent bound water |
|---|---|---|---|---|
| 1. Raw milk | 24 | 11.92 | 8.1 | 3.75 |
| 2. Milk pasteurized at 143° F. for 30 min. | 24 | 12.09 | 9.1 | 3.56 |
| 3. Milk pasteurized at 160° F. for 5 min. | 24 | 11.94 | 9.3 | 3.06 |
| 4. Milk pasteurized at 180° F. momentarily | 24 | 12.11 | 9.3 | 3.30 |
| 5. Raw cream | 0 | 40.25 | 5.0 | 5.39 |
| | 24 | 40.25 | 5.2 | 6.26 |
| 6. Cream pasteurized at 143° F. for 30 min. | 0 | 41.40 | 5.2 | 3.94 |
| | 24 | 41.40 | 5.3 | 5.11 |
| 7. Condensed skimmilk | 0 | 26.27 | 5.0 | 8.09 |
| | 24 | 26.27 | 5.3 | 10.97 |
| 8. Superheated condensed skimmilk | 0 | 26.43 | 5.7 | 8.99 |
| | 24 | 26.43 | 5.8 | 10.57 |

The aging of dairy products at low temperatures for 24 hours does not have any marked effect upon the alcohol stability, although the trend throughout this work (1, 2) does in some cases show a slight increase in alcohol stability with the increase in bound water content. In most cases the alcohol stability determination either showed that a slight increase or no change in stability resulted upon aging the sample.

That high heat treatment usually results in a decrease in bound water content and an increase in alcohol stability is shown in Tables 2, 3 and 10.

It was found by the writers in a previous investigation (2) that homogenization decreased the bound water content of milk plasma mixes containing butterfat and also decreased the alcohol stability. As the pressure is increased there is an increase in the degree of fat clumping and a decrease in the alcohol stability and bound water content. Dual homogenization decreased the fat clumping, increased the bound water content, and also increased the alcohol stability of the mix.

The results noted in Table 10 indicate that some dairy products, notably cream and condensed skimmilk, do increase in alcohol stability and bound water content on aging.

Previous results (2) also show that milk stabilizing salts slightly increased the alcohol stability and bound water content, while the milk destabilizing salts decreased the alcohol stability and the bound water content.

## SUMMARY AND CONCLUSIONS

The bound water content of the milk colloids does not appear to contribute to the creaming ability of milk. High temperature treatment of the whole milk or skimmilk is detrimental to the creaming ability and bound water content of the milk while high temperature treatment of the cream portion does not affect creaming to any great extent.

The increase of the specific gravity of fresh milk and skimmilk on aging (Rechnagel's phenomenon) is thought to be partially due to the increase in the bound water content of the proteins and other hydrophilic substances present in milk.

Vacuum roller dry skimmilk loses some of its bound water with age. The greatest amount is lost during the first few weeks of storage. The dry skimmilk stored in open containers was affected more than the dry skimmilk stored in air-tight containers.

Superheating of condensed skimmilk had no appreciable effect upon the bound water content.

Short aging periods of concentrated milk plasma at relatively high temperatures resulted in only slightly more bound water than longer aging periods at low temperatures.

Invariably aging caused an increase in bound water content, regardless of the treatment given the sample.

The Dahlberg and Hening method of increasing the viscosity of cream by temperature treatment resulted in an increase in the bound water content of the cream.

Pasteurization of milk or cream lowered viscosity and bound water content.

Homogenization of mixes with one pressure increased viscosity and decreased the bound water content, while dual homogenization of the same product showed an increase in bound water content and viscosity.

The protein stability as measured by the alcohol number usually showed little change with changes in bound water content unless large changes were noted in the amount of bound water present. However, heating of milk to high temperatures decreased the bound water content but increased the stability toward alcohol, while superheating of condensed skimmilk resulted in increased stability with practically no change in bound water content.

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# THE RELATION BETWEEN ACID DEFECTS AND HYDROGEN ION CONCENTRATION IN BRICK CHEESE

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Measurements of hydrogen ion concentration have proved to be a useful means of following acid development in American (1, 6, 7, 8) and Swiss cheese (2, 3, 4, 5) during manufacturing and the early part of curing. These measurements in American cheese are so closely related to the flavor and body characteristics of the ripened cheese that they can be used advantageously in the control of acid. Observations are reported in this discussion which seem to indicate that measurements of hydrogen ion concentration of Brick cheese during the first few days of curing may be a very useful guide for controlling subsequent manufacturing processes.

The successful making of Brick cheese with *Streptococcus lactis* starter requires the development of acidities which, if they are not carefully controlled, may cause defective cheese. The flavor, body and texture of Brick cheese are all directly influenced by the acidity development. Excessive amounts of acid delay ripening, cause undesirable acid or sour flavors, and crumbly, mealy bodied cheese. Low acidity, on the other hand, encourages the development of abnormal, gassy fermentations and causes excessively open texture and abnormal flavors in the cheese. Increases in the yield are usually attempted by reducing the acidity so that more moisture will be retained in the cheese. Such manipulations may produce very sweet or, what is more surprising, very acid cheese.

It is not always easy to detect abnormally acid or sweet cheese by sense of taste or body characteristics soon enough in the curing process to prevent repetition of the fault. Measurements of hydrogen ion concentration were, therefore, made during the first week of curing 72 lots of cheese and these values have been correlated with the criticisms of competent judges. The results are reported in this paper.

Acid measurements were made with the quinhydrone electrode, saturated calomel half-cell and a Leeds-Northrup portable potentiometer. Measurements are reported in pH units. Samples of cheese were taken by cutting each loaf in half across the long dimension and then removing a cross section slice. The whole slice, excluding the rind, was used for the analyses.

## DAILY VARIATIONS IN ACIDITY

Daily variations in acidities of 7 typical lots of Brick cheese are shown in Figure 1. Acid measurements were made on these lots when they were taken

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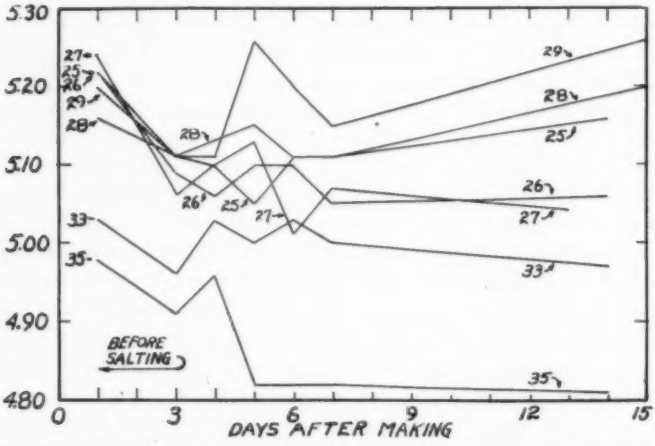
from the hoops just before salting, again on the third day just after salting, and daily, thereafter, until the 7th day after making. The last measurement was made at the time of paraffining on about the 14th day. All 7 lots varied somewhat in acid during this period, the maximum variation equaling 0.15 pH units. The pH on the third day after making approximated the minimum for most of the lots. Toward the end of the week the acidities generally approximated the values observed on the third day. During the second week the acid values of these seven lots became relatively divergent. Such variations must be expected because of sampling different loaves of cheese, changing salt concentrations, bacteriological activity and the limits of accuracy of the method of acid measurement.




CHANGES IN ACIDITY OF 7 LOTS OF BRICK CHEESE FROM SALTING TO PARAFFINING

FIG. 1

After the first week of curing there was in general, a slight increase in the average pH of all lots. This trend continued as the cheese ripened. Individual lots acted differently in rate of pH increase. Such variations explain why, during the later stages of ripening, individual lots of sweet and acid Brick cheese may actually have the same pH values. This has also been observed in ripening American cheese.

## RELATION BETWEEN ACIDITY OF CHEESE AND ACID DEFECTS

Forty-eight lots of Brick cheese have been classified in Table 1 according to the "Acid Grade." The acid grade indicates the degree of acidity in flavor and body detected by the judges. Satisfactory cheese is called "sweet" and given an acid grade of zero. "Trace of acid," "acid," "very acid" and "sour" indicate increasing degrees of acidity and are given grades of 1, 2,

3 and 4, respectively. The average pH values calculated for the cheese in each acid grade tended to decrease with the exaggeration of the defect. Sweet cheese had an average pH of 5.09 three days after making while sour cheese had an average pH of 4.92. Comparison of average values on the third and seventh days shows no significant differences. Actually the averages of the pH of all the cheese in the four acid grades were identical on these two days.

TABLE 1

*Average pH of Brick cheese in each acid grade*

| Acid grade | Number of lots | Average acidity | |
|---|---|---|---|
| | | 3 days after making | 7 days after making |
| | | *pH* | *pH* |
| Sweet | 28 | 5.09 | 5.12 |
| Trace of acid | 4 | 5.03 | 5.02 |
| Acid | 8 | 4.95 | 4.95 |
| Very acid | 3 | 4.99 | 5.03 |
| Sour | 5 | 4.92 | 4.91 |

The relation between acid measurements on the third and seventh days after making and the acid grade is shown in Figure 2. Numerical values representing the average acid grade for corresponding pH classes have been averaged, then plotted and a smooth curve has been drawn to fit the data obtained on the third day. Data from the seventh day were too scattered in the high acid range to justify a smooth curve. This figure, as well as Table 1, indicates that pH measurements as a whole were directly related to the flavor and body characteristics of the cheese. As the pH decreased, the cheese became increasingly acid in the opinion of the judges. Third day measurements, however, seem to be more closely related to the acid grade than those

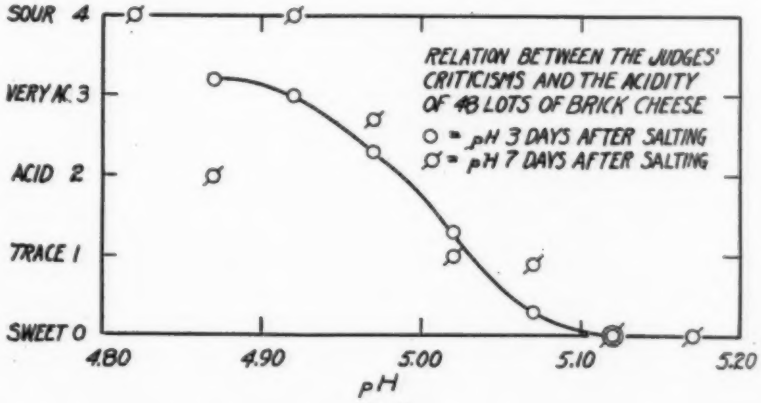



FIG. 2

obtained on the seventh day. Measurements on the fourth day after making approximate the significance of those on the third day.

Any degree of acid defect may be regarded as undesirable. All forty-eight lots of cheese were therefore divided into sweet and acid defective groups. The lots of cheese in each group were classified according to their acidity on the third day after making and the results are shown in Table 2.

TABLE 2

*Relation between the judges' criticisms and the acidity of Brick cheese 3 days after making*

| Acidity of cheese 3 days after making | Total of sweet and acid lots | Sweet cheese | |
|---|---|---|---|
| *pH* | *Number* | *Number* | *Per cent* |
| 5.10 to 5.19 | 14 | 14 | 100 |
| 5.00 to 5.09 | 21 | 13 | 62 |
| 4.90 to 4.99 | 9 | 1 | 11 |
| 4.80 to 4.89 | 4 | 0 | 0 |

When the pH of the cheese was 5.00 to 5.09 a slight majority of lots were sweet but there were almost as many acid defective cheese in this grade. Below pH 5.00 only one lot was called sweet. Table 3 illustrates the same arrangement of data obtained from measurements of pH on the seventh day. Here again pH values of 5.10 or more are associated only with sweet cheese, while below this value some cheese are sweet but more are acid defective. It seems safe to state that pH values of Brick cheese should never fall below 5.10 on the third day or seventh day after making if acid defective cheese is to be avoided.

TABLE 3

*Relation between the judges' criticisms and the acidity of Brick cheese 7 days after making*

| Acidity of cheese 7 days after making | Total of sweet and acid lots | Sweet cheese | |
|---|---|---|---|
| *pH* | *Number* | *Number* | *Per cent* |
| 5.20 to 5.29 | 3 | 3 | 100 |
| 5.10 to 5.19 | 17 | 17 | 100 |
| 5.00 to 5.09 | 16 | 8 | 50 |
| 4.90 to 4.99 | 7 | 0 | 0 |
| 4.80 to 4.89 | 5 | 0 | 0 |

Manufacturers or buyers may have difficulty in always measuring pH on the third day after making. Values of pH on other days as indicated in Figure 1 may vary widely from those made on the third day. However, even random measurements during the first seven days after making still have some value as indicated in Table 4. Here, pH measurements made on 72 lots of Brick cheese during the first week of curing have been classified in the same manner as the data in Tables 2 and 3. The highest or most favorable pH value observed for each lot during the first seven days after making was

selected as the basis of the acid classification in Table 4. Even when these values are used to predict the acid grade of the cheese the pH 5.10 standard still maintains its significance. The chances of making acid defective cheese are very slight when the pH during the first week of curing remains at 5.10 or more.

TABLE 4

*Relation between pH and quality when cheese is classified by the highest pH values observed during the first week after making*

| Highest pH observed during first week | Total of sweet and acid lots | Sweet cheese | |
|---|---|---|---|
| *pH* | *Number* | *Number* | *Per cent* |
| 5.20 to 5.29 | 4 | 4 | 100 |
| 5.10 to 5.19 | 27 | 26 | 93 |
| 5.00 to 5.09 | 21 | 7 | 35 |
| 4.90 to 4.99 | 15 | 1 | 6 |
| 4.80 to 4.89 | 5 | 0 | 0 |

Cheese buyers who receive Brick cheese after approximately two weeks of curing cannot apply so well the pH method of judging acidity. At two weeks of age the pH values of some lots of acid cheese may actually be well above the 5.10 standard of the first week of curing. This fact is illustrated in Table

TABLE 5

*Relation between the judges' criticisms and the acidity of Brick cheese at paraffining*

| Acidity of cheese at paraffining* | Total of sweet and acid lots | Sweet cheese | |
|---|---|---|---|
| *pH* | *Number* | *Number* | *Per cent* |
| 5.20 to 5.29 | 14 | 12 | 86 |
| 5.10 to 5.19 | 19 | 15 | 79 |
| 5.00 to 5.09 | 25 | 9 | 36 |
| 4.90 to 4.99 | 11 | 2 | 18 |
| 4.80 to 4.89 | 3 | 0 | 0 |

* Paraffining occurred 13 to 18 days after making.

5 which shows two acid lots of cheese with a pH of more than 5.20 and approximately two-thirds of all acid lots under observation above pH 5.00. Practically all pH values for sweet cheese fall in the same classes with about one-third in the pH 5.20 to 5.29 group. This over-lapping of the acidities of sweet and acid cheese at this time makes measurements of little value unless they happen to be extremely high or low. Actually, however, pH measurements are not necessary at this time, since by the fourteenth day after making, acid flavor and short body are easily detected by any competent judge.

## CONCLUSIONS

The pH of Brick cheese three days after making is a useful index of the acid characteristics of the ripened cheese. The minimum pH should not be

less than 5.1 at this time. The fact that the observed limit of acidity approximates that desired in American cheese indicates the similarity of the two types of cheese and emphasizes the significance of pH in controlling the elastic properties and the flavor of fresh cheese. Undoubtedly characteristic acidity limits distinguish other varieties of cheese.

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# DETECTING THE NEUTRALIZATION OF MILK WITH THE CRYOSCOPE

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In the examination of milk for the addition of neutralizers, it is frequently impossible to say definitely that a sample has been adulterated. This is probably due to the fact that the present tests which have been proposed are based on a characteristic or constituent of milk that is too variable.

Tillmans and Luckenback (11), for example, suggest a method (later modified by Sommer (9)), which is based on the difference between the buffer capacity of normal and neutralized milk of the same acidity.

Mojonnier (7) devised a method for the determination of lime in dairy products. If the amount of lime found in a suspected sample exceeds the normal amount, the sample may be considered to be neutralized.

The pH (6) may be determined either with indicators, such as brom thymol blue, or by the electrometric method; and neutralization may be deduced from an abnormally alkaline pH.

A method was proposed by Nottbohm (8) for determining the sodium–potassium ratio in the suspected milk. An abnormally greater proportion of sodium to potassium indicated neutralization.

Since the present methods are not generally accepted, it was thought that a method, to be acceptable, should be based upon some constant characteristic of milk such as the freezing point. A method such as this was published by Koenig and Kluge (5). Although they reported the results on only three neutralized samples of milk, the method appeared to be of value. They stated that if the corrected freezing point lies below – .554° C., neutralization is indicated. The corrected freezing point is obtained in the following manner: Subtract 7 from the observed Soxhlet-Henkel degrees acidity and multiply the result by .007. Subtract this figure from the observed freezing point.

In studying neutralized milk, the greatest difficulty involved is the wide variation of the original acidity of different samples of milk. Caulfield and Riddell (2) report variations from .098 to .295 per cent acidity of milk from cows in Kansas. Experience in this laboratory is in agreement with Caulfield and Riddell; a range of .09 to .245 per cent acidity was found in 4,000 samples of milk. Consequently, if an unknown sample of milk has an acidity of from .09 to .25 per cent it cannot be definitely regarded as sour, normal, or neutralized by the determination of acidity alone.

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Hortvet (3), Keister (4), Bailey (1), and others have done a considerable amount of work on the freezing point and its relation to the souring of milk. There are also many reports regarding the effect of heat, garget, colostrum, skimming, age of cow, breed of cow, period of lactation, season of the year, etc., all of which show that these factors have no appreciable effect upon the freezing point of pure milk. There was yet to be shown, therefore, the normal variations that might be expected between the developed acidity of normal milk and its freezing point. It was also necessary to show the effect of various neutralizers on the freezing point.

## EXPERIMENTAL

All of the work herein reported was done on samples of known purity from herds of two to twenty cows each. Each sample was examined for bacteria count, acidity, pH, and freezing point. It was then allowed to sour spontaneously and again examined for acidity, pH, and freezing point. The sour sample was then divided into two to eight parts depending upon the nature of the experiment and neutralized with NaOH, $NaHCO_3$, $Na_2CO_3$, and $MgCO_3$ in the dry form. These samples were in turn examined for acidity, pH, and freezing point. The relationship existing between pH and freezing point is not as definite as the one between acidity and freezing point. For this reason and for the sake of brevity, all the pH readings obtained are not reported. However, they were run on all samples as a check on the acidity.

Acidity was determined by pipetting 17.6 ml. of the sample into a white container, adding ½ ml. of 1 per cent phenolphthalein and titrating to a faint pink color with .1 N NaOH. The number of milliliters divided by 20 equals the per cent acidity calculated as lactic acid and was so recorded.

Bacteria counts were made on the fresh samples by the Breed direct method. In no case did the count exceed 300,000 and averaged 100,000 for all samples examined. The samples were therefore considered to be devoid of developed acidity.

Freezing points were determined with a Hortvet (3) cryoscope, the procedure given in Standard Methods of Milk Analysis (10) being followed exactly. A blower of the type used in electric insect spray guns was employed as a source of compressed air. An adjustable type vacuum windshield wiper, the arm of which was hooked to the stirrer, served as a means of mechanically agitating the milk during freezing.

The determinations of pH were made electrometrically with a quinhydrone electrode.

## RESULTS

Twenty-eight samples of raw milk were allowed to sour spontaneously and freezing points determined at various acidities. These results are given in Table 1. If each sample is plotted, it can be shown that there is a

TABLE 1

*Effect of souring on freezing point*

| Sample number | Acidity | Freezing point – °C. | Sample number | Acidity | Freezing point – °C. |
|---|---|---|---|---|---|
| 2 | .145 | .540 | 13 | .12 | .548 |
| | .18 | .568 | | .195 | .570 |
| 5554 | .145 | .557 | 224 | .14 | .557 |
| | .235 | .594 | | .175 | .567 |
| 682 | .22 | .550 | 899 | .155 | .548 |
| | .32 | .582 | | .19 | .558 |
| 3485 | .11 | .545 | 4018 | .15 | .547 |
| | .13 | .547 | | .22 | .575 |
| | | | | .32 | .609 |
| 4569 | .15 | .552 | | .36 | .637 |
| | .205 | .562 | | .40 | .645 |
| | .24 | .575 | | .50 | .677 |
| | .44 | .632 | | .60 | .716 |
| | .56 | .660 | | | |
| | .61 | .697 | 113 | .135 | .550 |
| | | | | .18 | .562 |
| 21 | .15 | .548 | | .24 | .588 |
| | .20 | .566 | | .39 | .638 |
| | .24 | .600 | | .50 | .697 |
| | .47 | .680 | | | |
| | .59 | .719 | 22 | .15 | .548 |
| | | | | .24 | .600 |
| 131 | .13 | .550 | | | |
| | .24 | .588 | 5290 | .155 | .540 |
| | | | | .30 | .590 |
| 2380 | .14 | .542 | | | |
| | .30 | .609 | 1854 | .15 | .558 |
| | | | | .21 | .580 |
| 36 | .135 | .558 | | | |
| | .23 | .578 | 4019 | .145 | .541 |
| | .35 | .620 | | .24 | .580 |
| | .37 | .622 | | .33 | .611 |
| | .53 | .675 | | .45 | .645 |
| | | | | .61 | .698 |
| 4408 | .155 | .551 | | | |
| | .215 | .580 | 3900 | .11 | .548 |
| | .295 | .601 | | .225 | .584 |
| | .41 | .631 | | .30 | .609 |
| | .53 | .674 | | .455 | .640 |
| | | | | .605 | .697 |
| 1333 | .15 | .540 | 1310 | .18 | .553 |
| | .23 | .562 | | .215 | .568 |
| | .295 | .592 | | | |
| | .375 | .632 | 371 | .155 | .533 |
| | .52 | .657 | | .295 | .576 |
| | | | 6137 | .165 | .542 |
| 370 | .165 | .540 | | .215 | .562 |
| | .215 | .560 | | | |
| | .33 | .599 | 5290 | .15 | .541 |
| | .46 | .632 | | .235 | .572 |
| | .57 | .674 | | | |
| | | | 5289 | .16 | .540 |
| 5328 | .16 | .550 | | .24 | .591 |
| | .20 | .590 | | | |

straight line relationship between developed acidity and freezing point. This relationship varies from sample to sample probably due to (a) differences in the original titratable acidity of the milk and (b) differences in the amount of lactose and any other fermentable substances present. The extremes found in all samples studied—including those of Keister's (4) and Bailey's (1) are shown in Figure 1.

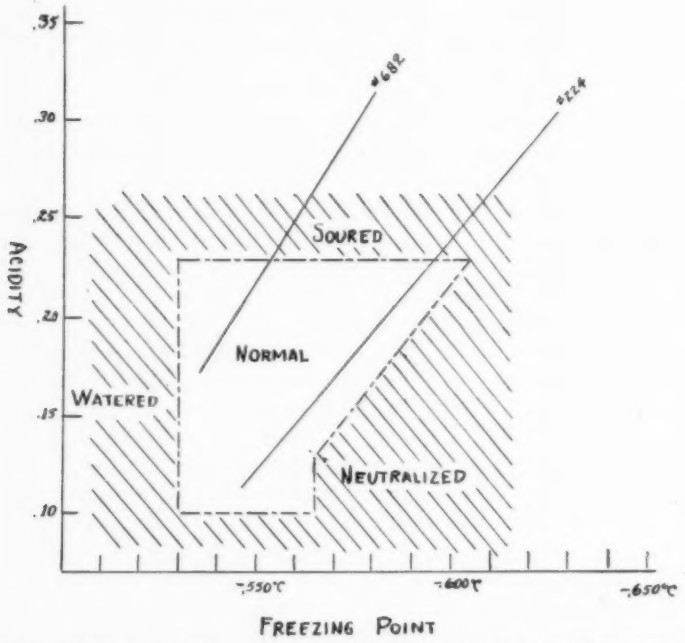


FIG. 1. Maximum (#224) and minimum (#682) freezing-point-acidity curves found in 40 samples of normal milk including those of Bailey's and Keister's. The shaded area represents abnormal milk.

It was recognized that only a small number of samples were tested and those from just one section of the country. A certain leniency, therefore, was allowed when determining whether or not a sample was neutralized. The shaded portion of Figure 1 was considered abnormal for pure milk and any point in this area was judged watered, neutralized, or soured according to its location.

In Table 2 is recorded the effect of the addition of four kinds of neutralizers on the freezing point and acidity. In columns eight and nine an attempt was made to characterize the sample as if it had been of unknown origin. This was based on the acidity and freezing point of the sample

according to Figure 1. If the location of the plotted point was in the shaded area, the sample was considered neutralized; if on the dotted line, doubtful; and if in the clear area, normal. As will be observed from the table, of the 45 samples that were neutralized from .015 to .29 per cent

TABLE 2

*Effect of neutralization on freezing point*

| Sample number | Normal | | Soured | | Neutralized | | Max. fr. pt. allowable for acidity, if normal. −°C. | Characterization of sample, if unknown |
|---|---|---|---|---|---|---|---|---|
| | Acid % | Fr. pt. −°C. | Acid % | Fr. pt. −°C. | Acid % | Fr. pt. −°C. | | |
| (neutralized with $NaHCO_3$) | | | | | | | | |
| 2 | .14 | −.540 | .205 | −.568 | .12 | −.608 | −.565 | neutralized |
| 13 | .12 | .548 | .195 | .570 | .125 | .608 | .565 | " |
| 554 | .145 | .557 | .235 | .594 | .15 | .634 | .575 | " |
| 224 | .14 | .557 | .175 | .567 | .145 | .572 | .570 | doubtful |
| 682 | .22 | .550 | .32 | .582 | .22 | .607 | .600 | " |
| 899 | .155 | .548 | .19 | .558 | .15 | .581 | .575 | neutralized |
| 3485 | .11 | .545 | .13 | .547 | .11 | .560 | .565 | normal |
| 22 | .15 | .548 | .24 | .600 | .215 | .741 | .597 | neutralized |
| 131 | .13 | .550 | .24 | .588 | .12 | 1.450 | .565 | " |
| 1310* | .18 | .553 | .215 | .568 | .14 | .652 | .570 | " |
| 370* | .165 | .540 | .215 | .560 | .145 | .800 | .575 | " |
| 370 | .165 | .540 | .215 | .560 | .20 | .864 | .595 | " |
| 371* | .155 | .533 | .295 | .576 | .115 | .995 | .565 | " |
| 6137* | .165 | .542 | .215 | .562 | .15 | .646 | .575 | " |
| 5290* | .15 | .541 | .235 | .572 | .16 | .650 | .577 | " |
| 5328* | .16 | .550 | .255 | .585 | .19 | .651 | .590 | " |
| (neutralized with $Na_2CO_3$) | | | | | | | | |
| 2900* | .11 | .548 | .225 | .584 | .16 | .628 | .577 | " |
| 3900 | .11 | .548 | .225 | .584 | .12 | .615 | .565 | " |
| 371* | .155 | .533 | .295 | .576 | .06 | .672 | .565 | " |
| 6137* | .165 | .542 | .215 | .562 | .105 | .600 | .565 | " |
| 5290* | .15 | .541 | .235 | .572 | .12 | .621 | .565 | " |
| 5289 | .16 | .540 | .24 | .591 | .14 | .630 | .570 | " |
| 5328* | .16 | .550 | .255 | .585 | .185 | .604 | .585 | " |
| (neutralized with NaOH) | | | | | | | | |
| 5290 | .155 | .540 | .30 | .590 | .01 | .640 | .565 | " |
| 2388 | .14 | .542 | .30 | .609 | .08 | .628 | .565 | " |
| 2 | .15 | .548 | .24 | .600 | .12 | .600 | .565 | " |
| 1854 | .15 | .558 | .21 | .580 | .18 | .596 | .585 | " |
| 13 | .14 | .550 | .21 | .561 | .15 | .582 | .575 | doubtful |
| 36* | .135 | .558 | .23 | .578 | .12 | .580 | .565 | neutralized |
| 4019 | .145 | .541 | .24 | .580 | .125 | .592 | .565 | " |
| 4019* | .145 | .541 | .24 | .580 | .105 | .589 | .565 | " |
| 4408 | .155 | .551 | .215 | .580 | .16 | .582 | .577 | doubtful |
| 4408* | .155 | .551 | .215 | .580 | .155 | .580 | .575 | " |
| 1310* | .18 | .553 | .215 | .568 | .155 | .570 | .575 | normal |
| 371* | .155 | .533 | .295 | .576 | .09 | .591 | .565 | neutralized |
| 6137* | .165 | .542 | .215 | .562 | .02 | .580 | .565 | " |
| 5290* | .15 | .541 | .235 | .572 | .04 | .584 | .565 | " |
| 5328* | .16 | .550 | .255 | .585 | .20 | .590 | .600 | normal |

TABLE 2.—(*Continued*)

| Sample number | Normal | | Soured | | Neutralized | | Max. fr. pt. allowable for acidity, if normal. – °C. | Characterization of sample, if unknown |
|---|---|---|---|---|---|---|---|---|
| | Acid % | Fr. pt. – °C. | Acid % | Fr. pt. – °C. | Acid % | Fr. pt. – °C. | | |
| | | | | (neutralized with $MgCO_3$) | | | | |
| 36 | .135 | .558 | .23 | .578 | .12 | .578 | .565 | neutralized |
| 1333 | .15 | .540 | .23 | .562 | .20 | .565 | .595 | normal |
| 1310* | .18 | .553 | .215 | .568 | .17 | .595 | .582 | neutralized |
| 371 | .155 | .533 | .295 | .576 | .04 | .580 | .565 | " |
| 6137* | .165 | .542 | .215 | .562 | .14 | .562 | .570 | normal |
| 5290* | .15 | .541 | .235 | .572 | .155 | .588 | .575 | neutralized |
| 5328* | .16 | .550 | .255 | .585 | .175 | .586 | .582 | doubtful |

* Neutralized portions heated to 160° F. for 20 seconds.

acidity, 5 would have been considered normal, 4 doubtful, and 36 neutralized.

Since it was necessary to heat the neutralized samples in order to obtain the correct acidity and also to assist the neutralization reaction, a study was made of the effect of heating on neutralized samples of milk. The samples were heated to 160° F. for 20 seconds and cooled immediately. Some of these results are given in Table 3. It was found that heat has a

TABLE 3

*Effect of heat on freezing point of normal, soured, and neutralized samples*

| Sample | | Normal | Normal heated | Soured | Soured heated | Neutralized | Neut. heated |
|---|---|---|---|---|---|---|---|
| 4019 (NaOH) | acid | .145 | .13 | .24 | .235 | .125 | .105 |
| | pH | 6.60 | 6.66 | 6.06 | 6.15 | 6.61 | 6.81 |
| | fr. pt. | .541 | .544 | .580 | .579 | .592 | .589 |
| 4408 (NaOH) | acid | .155 | .15 | .215 | .215 | .16 | .155 |
| | pH | 6.55 | 6.57 | 6.20 | 6.17 | 6.63 | 6.58 |
| | fr. pt. | .551 | .550 | .580 | .579 | .582 | .580 |
| 3900 ($Na_2CO_3$) | acid | .11 | .105 | .225 | .205 | .16 | .12 |
| | pH | 6.87 | 6.87 | 6.03 | 6.15 | 6.61 | 6.83 |
| | fr. pt. | .548 | .549 | .584 | .579 | .628 | .615 |
| 1333 ($MgCO_3$) | acid | .15 | .14 | .23 | .21 | .20 | .14 |
| | pH | 6.69 | 6.72 | 6.21 | 6.35 | 6.46 | 6.72 |
| | fr. pt. | .540 | .538 | .562 | .559 | .565 | .560 |
| 370 ($NaHCO_3$) | acid | .165 | .15 | .215 | .21 | .20 | .145 |
| | pH | 6.61 | 6.60 | 6.40 | 6.37 | 7.09 | 7.49 |
| | fr. pt. | .540 | .538 | .560 | .560 | .864 | .800 |

variable effect upon the freezing point of a neutralized sample depending upon the kind of neutralizer used. In all cases, the freezing point of the heated neutralized sample was higher than the same sample which was not heated and lower than the soured sample that was not neutralized. This

indicates that once a sample of milk has been neutralized, heating will not affect the accuracy of the cryoscopic method of detection of neutralization.

The effect of different neutralizers on the freezing point of the same sample was next considered. In this study, an attempt was made to neutralize the samples to the same acidity or pH. This was found difficult particularly since all neutralizers were added in the dry form to relatively small amounts of milk (200 ml.). Furthermore, the true acidity could not be determined until after the sample had been heated. It was thought inadvisable to heat the sample more than once since prolonged heating would have a concentrating effect and therefore alter the freezing point. It was found that NaOH and $MgCO_3$ depressed the freezing point the least, $Na_2CO_3$ next, and $NaHCO_3$ the most. Ordinary baking soda ($NaHCO_3$) is probably most frequently used as a neutralizer on the farm, which, fortunately, has been shown to be the easiest to detect. These results are given in Table 4.

TABLE 4

*Effect of different neutralizers on same sample*
(Neutralized samples heated)

| Sample | | Normal | Soured | Neut. NaOH | Neut. $NaHCO_3$ | Neut. $Na_2CO_3$ | Neut. $MgCO_3$ |
|---|---|---|---|---|---|---|---|
| 36 | acid | .135 | .235 | .12 | ..... | ..... | .12 |
| | pH | 6.61 | 6.14 | 6.76 | ..... | ..... | 6.85 |
| | fr. pt. | .558 | .578 | .580 | ..... | ..... | .579 |
| 1310 | acid | .18 | .215 | .155 | .14 | .14 | .17 |
| | pH | 6.51 | 6.29 | 6.60 | 7.02 | 6.70 | 7.23 |
| | fr. pt. | .553 | .568 | .570 | .652 | .600 | .595 |
| 371 | acid | .155 | .295 | .09 | .115 | .06 | .04 |
| | pH | 6.55 | 5.89 | 7.01 | 7.61 | 7.41 | 7.60 |
| | fr. pt. | .533 | .576 | .591 | .995 | .672 | .580 |
| 6137 | acid | .165 | .215 | .02 | .15 | .105 | .14 |
| | pH | 6.58 | 6.27 | 8.25 | 6.82 | 7.03 | 6.73 |
| | fr. pt. | .542 | .562 | .580 | .646 | .600 | .562 |
| 5290 | acid | .15 | .235 | .04 | .16 | .12 | .155 |
| | pH | 6.61 | 6.15 | 7.80 | 6.82 | 6.97 | 6.63 |
| | fr. pt. | .541 | .572 | .584 | .650 | .621 | .588 |
| 5328 | acid | .16 | .255 | .20 | .19 | .185 | .175 |
| | pH | 6.59 | 6.14 | 6.56 | 6.76 | 6.55 | 6.59 |
| | fr. pt. | .550 | .585 | .590 | .651 | .604 | .586 |

The next question of interest was the effect of further souring on the freezing point of a neutralized sample. As will be seen from a study of Table 5, the straight line relationship of freezing point and acidity is still maintained in the range studied (up to .60 per cent). However, the depression of the freezing point due to neutralization persists. These results are shown graphically in Figure 2, and from them, it may be concluded that

TABLE 5

*Effect of further souring after neutralization on freezing point*

| Sample | | Normal | Soured | Neut. | Neut. and soured | Neut. and soured |
|---|---|---|---|---|---|---|
| 5328 (NaOH) | acid | .16 | .255 | .20 | .26 | .41 |
| | pH | 6.59 | 6.14 | 6.56 | 6.20 | 5.58 |
| | fr. pt. | .550 | .585 | .590 | .612 | .671 |
| 5328 ($NaHCO_3$) | acid | .16 | .255 | .19 | .235 | .38 |
| | pH | 6.59 | 6.14 | 6.76 | 6.48 | 5.67 |
| | fr. pt. | .550 | .585 | .651 | .665 | .725 |
| 5328 ($Na_2CO_3$) | acid | .16 | .255 | .185 | .28 | .36 |
| | pH | 6.59 | 6.14 | 6.55 | 6.03 | 5.78 |
| | fr. pt. | .550 | .585 | .604 | .640 | .670 |
| 5328 ($MgCO_3$) | acid | .16 | .255 | .175 | .39 | .375 |
| | pH | 6.59 | 6.14 | 6.59 | 5.94 | 5.87 |
| | fr. pt. | .550 | .585 | .586 | .637 | .670 |
| 5289 ($Na_2CO_3$) | acid | .16 | .24 | .14 | .23 | ..... |
| | pH | 6.58 | 6.13 | 6.93 | 6.37 | ..... |
| | fr. pt. | .540 | .591 | .630 | .660 | ..... |
| 22 ($NaHCO_3$) | acid | .15 | .24 | .215 | .30 | .46 |
| | pH | 6.62 | 6.01 | 6.79 | 6.31 | 5.83 |
| | fr. pt. | .548 | .600 | .741 | .836 | .897 |
| 2388 (NaOH) | acid | .14 | .30 | .08 | .33 | .42 |
| | pH | 6.58 | 5.97 | 6.90 | 5.60 | 5.42 |
| | fr. pt. | .542 | .609 | .628 | .725 | .771 |
| 2 (NaOH) | acid | .15 | .24 | .12 | .21 | .34 |
| | pH | 6.62 | 6.01 | 6.58 | 6.08 | 5.56 |
| | fr. pt. | .548 | .600 | .600 | .670 | .721 |

further souring does not affect the accuracy of the cryoscopic method for the detection of neutralization.

As a check on the way an inexperienced worker would be able to detect neutralizer, an assistant was given 14 samples of milk of unknown origin. To some of these samples $NaHCO_3$ had been added in amounts varying from a tablespoon (8 gm.) to ½ cup (160 gm.) per 10 gallons of milk. He was then asked to judge the milk by acidity and freezing point alone without knowing if the samples had been neutralized or not. His results given in Table 6, indicate that he failed to detect neutralizer in No. 6 (possibly because the original sample may have been watered) and considered the sample containing a tablespoon of baking soda per 10 gallons of milk as doubtful. These results indicate that the test requires no special knowledge other than that of the maximum freezing points allowable for pure milk.

## DISCUSSION

It is recognized that only a few samples of milk have been studied in determining the efficiency of this test. It was felt, however, that the num-

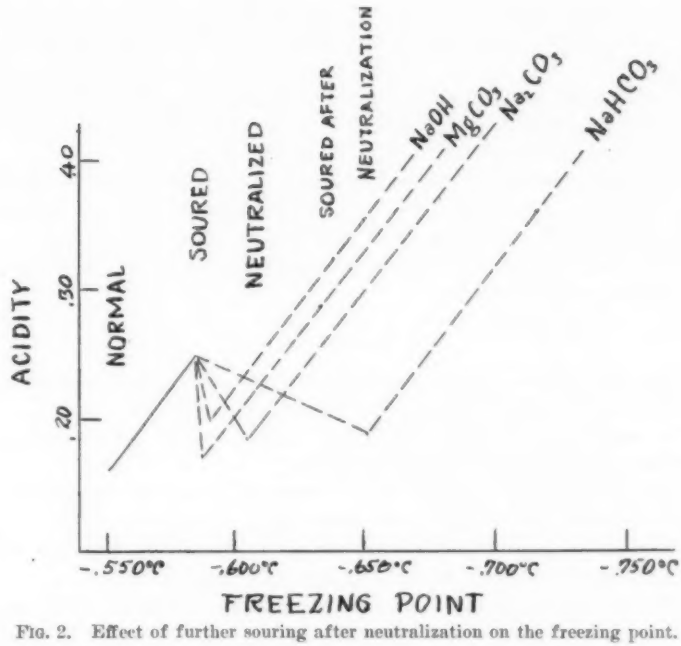


FIG. 2. Effect of further souring after neutralization on the freezing point.

TABLE 6

*Results obtained on "prepared unknowns" as analyzed by an inexperienced worker*

| Sample number | Original sample | | Results | | |
|---|---|---|---|---|---|
| | Acid | Amount neutralizer added to 10 gal. milk | Acid | Fr. pt. −°C. | Remarks |
| 1 | .15 | none | .155 | .482 | watered |
| 2 | .15 | " | .15 | .559 | normal |
| 3 | .18 | " | .27 | .521 | sour—watered |
| 4 | .18 | " | .455 | .628 | " —normal |
| 5 | .25 | 80 grams | .23 | .650 | neutralized |
| 6 | .28 | " | .25 | .540 | sour—normal (possibly watered) |
| 7 | .20 | " | .165 | .645 | neutralized |
| 8 | .265 | 8 grams | .26 | .622 | sour—normal (possibly neutralized) |
| 9 | .30 | 160 grams | .245 | .754 | neutralized |
| 10 | .22 | 40 grams | .19 | .643 | " |
| 11 | .21 | " | .20 | .624 | " |
| 12 | .195 | " | .18 | .609 | " |
| 13 | .19 | 80 grams | .165 | .611 | " |
| 14 | .24 | " | .235 | .647 | " |

ber was sufficient to warrant its use in this particular section of the country, and it is hoped that work can be done elsewhere which will prove or disprove the value of this test. It has been used in this plant for several months and in the few neutralized samples found by this test, the producer admitted using baking soda. It may be said that this test has definitely increased the efficiency of our field work among the producers.

It is further hoped, that should this test prove satisfactory for milk, it can also be applied to cream. Some preliminary work done here indicated that once a maximum allowable freezing point-acidity curve has been established for cream of a certain fat percentage, the addition of small amounts of neutralizer can be detected.

## CONCLUSIONS

1. There is a direct relationship between developed acidity and freezing point which varies only slightly from one sample to another.

2. Neutralizers such as NaOH or $MgCO_3$ do not lower the freezing point appreciably when used in necessary quantities.

3. Neutralizers such as $Na_2CO_3$ or $NaHCO_3$ lower the freezing point appreciably when used in necessary quantities.

4. Heating a neutralized sample tends to raise the freezing point slightly, but not enough to interfere with the accuracy of the test.

5. Neutralization of as little as .015 per cent can be detected depending upon the normal acidity of the neutralized sample and the kind of neutralizer employed.

6. Samples of milk with a low natural acidity (.10–.13 per cent) can be soured and neutralized as much as .075 per cent with NaOH without detection by this test.

7. After a sample has been neutralized, further souring will not affect the accuracy of the test.

8. The evidence available indicates that neutralization of milk can be detected by comparing the freezing point of the sample with the maximum allowable freezing point for a sample of that acidity.

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# AN IMPROVED AND MODIFIED EVENSON COLOR TEST FOR "REMADE MILK"

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Due to complaints by various health officials regarding mislabelling of remade milk an investigation was made of the methods for detection of remade milk in fluid milk.

Since the principle upon which Evenson based his studies of remade milk (1, 2, 3, 4) seemed the most promising of all the others listed in the literature (5, 6, 7, 8) it was studied first. Evenson's method had the added advantage of having been published and used in several similar instances. Several other methods based on different principles were tried but as the following modification of the Evenson method gave such promising results the others were discontinued.

Pipette 45 to 50 cc. of liquid milk into a centrifuge tube and precipitate the protein by the use of 5 per cent acetic acid. Centrifugalize and decant the supernatant liquid, wash the protein with distilled water, using a mechanical stirrer to break up the lumps. Again centrifugalize and decant. Extract fat from the protein by washing with 50 cc. portions each of acetone, ether, and acetone in the order named, using the mechanical stirrer to secure efficient disintegration of the particles of protein. Then continue the washing with distilled water, using the mechanical stirrer in every case until two successive washings give negative "Molisch Tests" for carbohydrates.

After two consecutive washings which show no presence of carbohydrates with the "Molisch Test" add approximately 15 cc. of a NaOH solution (225 gms. NaOH made up to 500 cc.) to the protein precipitate in the tube and mix with a stirring rod until all of the protein has been broken up and wetted with the NaOH. After two hours judge the tubes for their color against a known sample of liquid milk which has been carried through the above procedure. The samples containing the remade milk will show a distinctly yellow color while the other will not.

The judging of the colors of the protein should be made in daylight and not under electric lights.

## EXPERIMENTAL

Evenson in his article states that the method as he reported it would detect the addition of 10 per cent of remade milk in the liquid milk, but it

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was believed possible to make this test more sensitive if a more thorough washing of the precipitated protein could be perfected.

At the beginning of the experimental work the protein was precipitated out of 25 cc. of liquid milk in a 50 cc. centrifuge tube with a 5 per cent solution of acetic acid. The whey was then removed by centrifugalization and on each addition of wash water to the protein in the tube the protein was broken up by a stirring rod and centrifuged off. This method of washing was very effective and gave results more sensitive than Evenson's method of washing. However, it required some twenty to twenty-five washings in order to remove the last traces of lactose. The number of washings required so much time that some further modification was sought. This led to the use of a mechanical stirrer which could be used as a means of breaking up the curd. This materially assisted in washing the protein free of any uncombined lactose, for it breaks the particles up to a degree of fineness which assures complete removal. It was found that with the mechanical stirrer it was necessary to increase the size of sample used from 25 cc. to 50 cc., since more protein is lost during the washing.

TABLE 1

| Liquid milk number | Per cent remade milk added | Color | Remarks |
|---|---|---|---|
| 1 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 2 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 3 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 4 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | Did not show color with 5% but 10% showed color equal to 5% in other samples. |
| 5 | 0 | − | |
| | 5 | − | |
| | 10 | + | |
| 6 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 7 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 8 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |
| 9 | 0 | − | |
| | 5 | +(?) | (Very slight yellow) |
| | 10 | + | |
| 10 | 0 | − | |
| | 5 | + | |
| | 10 | ++ | |

− No yellow color.
+ Distinct yellow.
++ Very decided yellow color.

The mechanical mixer used in this laboratory was a Bodine laboratory motor with a rheostat. The motor was equipped with a stirrer made from a glass rod with a corkscrew twist on the end to give a mixing effect. This was so arranged on a ring stand that the 50 cc. conical centrifuge tube could be clamped in place during the mixing. If a 100 cc. tube with a flat bottom is used an ordinary malted milk mixer can be conveniently employed.

It was also found during the experimental work that by using a more concentrated NaOH solution (225 gms. NaOH made up to 500 cc.) instead of the 5 per cent solution, along with the mechanical mixing, that a 5 per cent addition of remade milk could be detected without any question. The depth of color, however, depends a great deal upon the degree of heat used in the processing of the powdered milk.

The samples of milk used in this work were pasteurized milk picked up in the Chicago area and were carried through the above procedure, using 5 per cent and 10 per cent additions of remade milk from various types of spray process dry milk. The results on a few of these samples are listed in Table 1.

It will be noted that in two of the samples listed above the five per cent addition did not show up as clearly as in the majority of cases. This undoubtedly is due to the degree of heat used in the processing of the powdered milk and the extent of reaction between the lactose and the protein. However, in all of the samples which were studied there was not a single sample of liquid milk which gave a positive test unless remade milk had been added.

A large number of raw milk samples picked up in another large city were run through the above test with equally good results.

## DISCUSSION

Evenson stated that his method would detect the addition of 10 per cent of remade milk in the liquid milk. It was found, however, that by the previously outlined procedure of washing the protein and using the more concentrated NaOH solution, that a 5 per cent addition of remade milk could be detected without any question. The depth of color, however, depends a great deal upon the degree of heat used in the processing of the powdered milk.

The use of the mechanical mixer very materially assists in washing the protein free of any uncombined lactose. Its use is essential for breaking up the particles of protein to the degree of fineness which assures a complete removal of the lactose. Use of the "Molisch Test" for carbohydrates has been recommended to indicate when the precipitate is adequately washed. The Molisch Test may be eliminated after the operator has gained experience and knowledge enough to know the effectiveness of his washing. It was found in this laboratory following our system of washing that ten washings after the fat extraction were sufficient.

During the work on this method it was observed that old fluid milks showed a grayish brown coloration with the NaOH solution but this was distinctly different from the yellow coloration of the remade milk. Even though there is a distinct difference, the grayish brown color does interfere with distinguishing the presence of the lower percentages of remade milks. The color comparisons must also be made in daylight and not under electric lights.

The development of the yellow color usually begins to appear in a few minutes after the mixing with the NaOH and reaches a maximum in 1½ and 2 hours. It was found that the contrast is more striking at the two hour period than later when an off-color begins to develop in the curd. This off-color interferes with the readings. However, the contrast is still apparent at the end of 24 hours.

## SUMMARY

Modifications have been made in Evenson's color test for "Remade Milk" which facilitates the detection of 5 per cent of remade milk in fluid milk.

The modifications made in the Evenson test are an improved method of washing the protein and the use of a stronger solution of sodium hydroxide which gives a more striking contrast between remade milks and natural milks.

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# RELATION BETWEEN RATE OF GROWTH AND MILK AND FAT PRODUCTION

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The efforts of research workers, breeders, and dairy farmers have been aimed for many years at ways and means of predicting production in dairy females before they were in milk. If some means could be devised to make such predictions at a period before the animals calved, a considerable saving would result and the breeding of dairy cattle would be facilitated. Prentice (1) has presented studies of the food consumption of calves which show correlation with their production at a later time. Turner (2) has intimated from his studies that the functioning of the pituitary might be closely related to milk production. It seemed, therefore, that a study of the rate of growth of young animals as correlated with the milk and fat production might yield results of interest. From the growth records of the University of Nebraska Holstein herd, 76 females were selected for this study. These animals were bred, reared, and tested for production in the herd under conditions that were as near comparable as possible. Furthermore, the animals were all closely related, since all were descended from families that have been closely related for about 30 years.

In making this study, three indices of growth were used, namely, gain in weight, increase in height at withers, and increase in chest girth. The birth measurements were compared with those at two years, and the percentage increase in the various measurements used as the rate of growth. Weights were determined by monthly weighings taken from three successive days and the average used. Measurements of height at withers were taken monthly with a calibrated measuring rod with a right-angle cross arm. The heights were measured in centimeters at the second dorsal vertebra when the animal was standing squarely on its four legs. The chest girth was taken in centimeters with a tape line around the chest, at the second dorsal vertebra at the top and just back of the elbows.

Table 1 presents the weights and measurements at birth and at two years, with the increase and percentage of increase for all Holsteins (3) compared with the average of the 76 females used in this study. It will be noted that there is a very close agreement between the standard as represented by all Holsteins in the table and the animals used in this study.

In order to study the possible relationship of gain in weight, increase in

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TABLE 1

*Measurements of Holstein females at birth and two years with percentage increases*

| Type of measurement | Birth measurements | Two years measurements | Increase in measurements | Increase in per cent |
|---|---|---|---|---|
| Average of all Holsteins* Weight, lbs. | 91 | 1108 | 1017 | 1117.6 |
| Average 76 Females Weight, lbs. | 87 | 1149 | 1022 | 1220.6 |
| Average of all Holsteins* Chest girth, cm. | 76.2 | 188.0 | 111.8 | 146.6 |
| Average 76 Females Chest girth, cm. | 77.9 | 190.2 | 112.1 | 144.1 |
| Average of all Holsteins* Height at withers, cm. | 73.7 | 133.4 | 59.7 | 81.0 |
| Average 76 Females Height at withers, cm. | 74.3 | 133.5 | 59.2 | 79.7 |

* Reference 3.

height, and increase in chest girth, three factors which are used to measure growth, a study was made of each factor as it might be related to subsequent milk and butterfat production, both for the first lactation and for the lifetime average of lactations. Thus, in Table 2 the 76 Holstein females were arranged in classes in accordance with their percentage of gain in weight at two years over the birth weight. The class interval range was 50 per cent and the classes varied from 900–949.9 per cent to 1750–1799.9 per cent with a mean of 1220.6 per cent gain. When the various individual animals were assigned to the group into which each belonged because of percentage gain in weight, the average birth weight, the average weight at two years, the average milk and fat production for one year for the first lactation and for the lifetime average of lactations was determined for each class together with the range in production. To make all production records comparable they were corrected to maturity, 365 days, for three-time milking. Thus the range in milk production was from 11,996 to 26,670 pounds of milk, and in fat production from 476 to 878 pounds of fat for the first lactation, with a simple average of 18,283 pounds of milk and 666 pounds of fat. For the lifetime average of lactations the range was from 12,117 to 26,670 pounds of milk and from 476 to 873 pounds of fat with a simple average of 18,040 pounds of milk and 651 pounds of fat. No statistical computations were made, but an inspection of Table 2 will indicate quite definitely that there is no marked correlation between the percentage gain in weight during the first two years and the production of milk and fat.

Table 3 presents a like comparison based upon increase in height as measured in height at withers in centimeters. The average height at withers at birth was 74.3 cm. and at two years of age 133.5 cm., a percentage increase of 79.7. The individual females were grouped according to gain in height, with class intervals of two per cent. Thus, the lowest class interval was

TABLE 2

*Relationship of percentage of gain in weight two years over birth, with milk and butterfat production for first lactation and lifetime average*

| Weight | | | Animals | Production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | First lactation | | | | Lifetime average per lactation | | | |
| | | | | Milk | | Fat | | Milk | | Fat | |
| Birth | Two years | Gain at two years over birth | | Range | Average | Range | Average | Range | Average | Range | Average |
| *lbs.* | *lbs.* | *per cent* | *No.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 96 | 985 | 900– 949.9 | 1 | | 15,075 | | 583 | | 15,075 | | 583 |
| 105.5 | 1121.5 | 950– 999.9 | 2 | | 18,018 | 668–691 | 679 | 15,744–17,742 | 16,743 | 615–618 | 616 |
| 95.0 | 1073.0 | 1000–1049.9 | 5 | 15,124–18,277 | 13,376 | 590–680 | 637 | 15,124–17,315 | 16,213 | 569–624 | 594 |
| 93.8 | 1100.6 | 1050–1099.9 | 9 | 16,602–26,670 | 19,782 | 656–862 | 707 | 15,419–26,670 | 19,153 | 576–862 | 680 |
| 90.5 | 1112.6 | 1100–1149.9 | 8 | 11,996–22,080 | 18,116 | 476–806 | 651 | 13,088–22,080 | 18,276 | 494–775 | 649 |
| 87.4 | 1108.6 | 1150–1199.9 | 5 | 14,903–19,869 | 18,125 | 605–748 | 664 | 13,220–19,869 | 17,732 | 528–748 | 658 |
| 88.4 | 1174.1 | 1200–1249.9 | 13 | 12,829–23,262 | 17,602 | 501–816 | 661 | 12,117–21,123 | 17,454 | 488–752 | 639 |
| 86.8 | 1197.3 | 1250–1299.9 | 8 | 16,655–21,135 | 18,901 | 595–842 | 680 | 16,308–20,517 | 18,265 | 596–746 | 661 |
| 81.9 | 1163.5 | 1300–1349.9 | 8 | 13,844–23,675 | 17,554 | 476–878 | 650 | 13,995–20,468 | 17,422 | 476–762 | 633 |
| 80.2 | 1167.6 | 1350–1399.9 | 8 | 14,686–25,388 | 18,131 | 508–873 | 659 | 14,753–25,388 | 17,658 | 508–873 | 643 |
| 80.0 | 1218.5 | 1400–1449.9 | 4 | 15,268–23,276 | 19,306 | 562–739 | 653 | 15,310–23,276 | 19,979 | 535–741 | 673 |
| 71.0 | 1123.0 | 1450–1499.9 | 1 | | 15,019 | | 512 | | 15,596 | | 528 |
| 85.0 | 1400.0 | 1500–1549.9 | 1 | | 20,413 | | 720 | | 21,770 | | 764 |
| | | 1550–1599.9 | 0 | | | | | | | | |
| | | 1600–1649.9 | 0 | | | | | | | | |
| | | 1650–1699.9 | 0 | | | | | | | | |
| 65.0 | 1193.5 | 1700–1749.9 | 2 | 16,630–21,277 | 18,953 | | 713 | 19,013–23,222 | 21,142 | 702–803 | 752 |
| 60.0 | 1120.0 | 1750–1799.9 | 1 | | 21,775 | | 815 | | 20,979 | | 752 |
| Averages, All Animals | | | | | | | | | | | |
| 87 | 1149 | 1220.6 | | | 18,283 | | 666 | | 18,040 | | 651 |

TABLE 3

*Relationship of percentage gain in height at withers two years over birth, with milk and butterfat production for first lactation and lifetime average*

| Height at withers | | | Animals | Production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | First lactation | | | | Lifetime average per lactation | | | |
| | | | | Milk | | Fat | | Milk | | Fat | |
| Birth | Two years | Gain at two years over birth | | Range | Average | Range | Average | Range | Average | Range | Average |
| *cm.* | *cm.* | *per cent* | *No.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 74.5 | 128.0 | 70– 71.9 | 1 | | 20,517 | | 682 | | 20,517 | | 682 |
| 76.2 | 131.8 | 72– 73.9 | 4 | 16,692–20,696 | 18,692 | 607–667 | 644 | 15,614–20,696 | 18,505 | 569–678 | 633 |
| 75.2 | 131.0 | 74– 75.9 | 4 | 17,307–22,080 | 19,695 | 668–756 | 698 | 16,775–22,080 | 19,379 | 618–756 | 671 |
| 74.9 | 132.4 | 76– 77.9 | 18 | 11,996–21,247 | 17,215 | 476–734 | 637 | 13,088–21,770 | 17,305 | 508–746 | 634 |
| 75.2 | 134.5 | 78– 79.9 | 14 | 12,829–26,670 | 17,798 | 476–878 | 662 | 12,117–26,670 | 16,919 | 476–734 | 631 |
| 74.2 | 134.6 | 80– 81.9 | 14 | 14,546–25,388 | 19,436 | 584–873 | 715 | 14,546–25,388 | 19,398 | 584–873 | 710 |
| 72.4 | 132.4 | 82– 83.9 | 5 | 17,228–21,966 | 19,429 | 645–806 | 707 | 16,148–20,399 | 18,071 | 593–775 | 664 |
| 72.0 | 133.5 | 84– 85.9 | 6 | 14,686–23,262 | 17,494 | 512–816 | 616 | 15,310–18,926 | 16,620 | 528–684 | 591 |
| 71.0 | 133.2 | 86– 87.9 | 2 | 17,114–18,323 | 17,718 | 586–713 | 649 | 18,284–20,788 | 19,536 | 613–738 | 675 |
| 72.1 | 136.1 | 88– 89.9 | 4 | 14,356–19,869 | 17,979 | 551–728 | 639 | 13,995–21,123 | 18,692 | 526–728 | 642 |
| 72.0 | 137.0 | 90– 91.9 | 1 | | 19,232 | | 653 | | 19,232 | | 653 |
| 68.0 | 131.0 | 92– 93.9 | 1 | | 21,775 | | 815 | | 20,979 | | 752 |
| 70.0 | 136.0 | 94– 95.9 | 1 | | 16,943 | | 608 | | 15,899 | | 549 |
| | | 96– 97.9 | 0 | | | | | | | | |
| | | 98– 99.9 | 0 | | | | | | | | |
| 68.0 | 136.0 | 100–101.9 | 1 | | 16,630 | | 684 | | 19,013 | | 702 |
| Averages, All Animals | | | | | | | | | | | |
| 74.3 | 133.5 | 79.7 | | | 18,283 | | 666 | | 18,040 | | 651 |

TABLE 4

*Relationship of percentage gain in chest girth two years over birth, with milk and butterfat production for first lactation and lifetime average*

| Chest girth | | | Animals | Production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | First lactation | | | | Lifetime average per lactation | | | |
| | | | | Milk | | Fat | | Milk | | Fat | |
| Ave. at birth | Ave. at 2 yrs. of age | Gain at two years over birth | | Range | Average | Range | Average | Range | Average | Range | Average |
| *cm.* | *cm.* | *per cent* | *No.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 84.5 | 187.3 | 120–123.9 | 3 | 17,315–21,247 | 19,477 | 591–748 | 669 | 17,315–21,247 | 19,477 | 591–748 | 669 |
| 80.0 | 181.5 | 124–127.9 | 2 | 18,236–20,517 | 19,376 | 680–682 | 681 | 16,783–20,517 | 18,650 | 624–682 | 653 |
| 82.0 | 188.6 | 128–131.9 | 9 | 13,944–26,670 | 19,475 | 554–873 | 693 | 15,124–26,670 | 19,595 | 575–873 | 684 |
| 82.3 | 192.6 | 132–135.9 | 3 | 18,277–23,276 | 20,749 | 656–739 | 687 | 15,614–20,696 | 19,862 | 569–739 | 654 |
| 81.4 | 194.0 | 136–139.9 | 10 | 12,829–22,080 | 17,686 | 501–756 | 649 | 12,117–22,080 | 17,466 | 488–756 | 636 |
| 77.6 | 188.0 | 140–143.9 | 6 | 16,602–18,567 | 17,581 | 637–693 | 659 | 16,148–21,123 | 18,615 | 593–746 | 675 |
| 77.8 | 191.8 | 144–147.9 | 15 | 11,996–23,675 | 18,417 | 476–878 | 684 | 13,088–21,770 | 17,823 | 494–764 | 655 |
| 75.9 | 189.0 | 148–151.9 | 11 | 13,844–21,837 | 17,612 | 476–806 | 653 | 13,844–23,222 | 17,428 | 476–803 | 643 |
| 76.0 | 192.6 | 152–155.9 | 5 | 14,903–23,262 | 18,687 | 605–816 | 708 | 13,220–20,788 | 18,071 | 528–738 | 676 |
| 72.8 | 187.6 | 156–159.9 | 5 | 13,663–19,726 | 16,852 | 512–684 | 613 | 14,640–19,766 | 16,359 | 559–709 | 604 |
| 75.0 | 198.0 | 160–163.9 | 1 | | 17,410 | | 606 | | 17,410 | | 606 |
| 72.0 | 191.0 | 164–167.9 | 1 | | 14,753 | | 508 | | 14,753 | | 508 |
| 69.5 | 186.5 | 168–171.9 | 2 | 16,630–21,966 | 19,298 | 684–718 | 701 | 19,013–19,073 | 19,043 | 615–702 | 658 |
| 69.0 | 189.0 | 172–175.9 | 3 | 14,356–21,775 | 17,989 | 551–815 | 674 | 13,995–20,979 | 17,194 | 526–752 | 637 |
| Averages, All Animals | | | | | | | | | | | |
| 77.9 | 190.2 | 144.1 | | | 18,283 | | 666 | | 18,040 | | 651 |

70–71.9 per cent and the highest 100–101.9 per cent. The lowest average of any class interval group had a height at birth of 68.0 cm., the highest average of a class interval group a height of 76.2 cm. At two years of age, the lowest average of any group was 128.0 cm. and the highest was 137.0 cm. The milk and fat production ranges and averages were much the same as in Table 2. An inspection of this table reveals no apparent correlation between rate of increase or growth in height, as measured in height of withers from birth to two years, and the production of milk and fat.

In Table 4 the increase in girth between birth and two years as measured in chest girth is presented in relation to production. The average chest girth at birth was 77.9 cm. and at two years it was 190.2 cm., an increase of 144.1 per cent. The individual females were grouped according to percentage increase in chest girth in four per cent class intervals. The classes ranged from 120.0–123.9 per cent to 172.0–175.9 per cent. Chest girth at birth varied in class interval averages from 69.0 cm. to 84.5 cm., while at two years the lowest class interval average was 181.5 cm. and the highest 198.0 cm. Here, again, the production showed much the same range and average, and an inspection of Table 4 will very definitely indicate the lack of correlation between increase in chest girth and production.

## SUMMARY AND CONCLUSIONS

An attempt was made to correlate rapidity of growth as indicated by gain in weight, by increase in height at withers, and by increase in chest girth from birth to two years, with milk and fat production for the first lactation and for the lifetime average of lactations. Seventy-six Holstein females in the University of Nebraska dairy herd were used. While the animals were apparently normal as compared with standards established in that herd, no apparent correlation was observable for any of the three measurements.

## REFERENCES

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(2) Turner, Chas. W. Unpublished data.
(3) Davis, H. P., Morgan, R. F., Brody, Samuel, and Ragsdale, A. C. Relation of height at withers and chest girth to live weight of dairy cattle of different breeds and ages. Nebraska Agric. Exper. Sta. Res. Bull. 91. July, 1937.

# A MANGER FOR EXPERIMENTAL FEEDING

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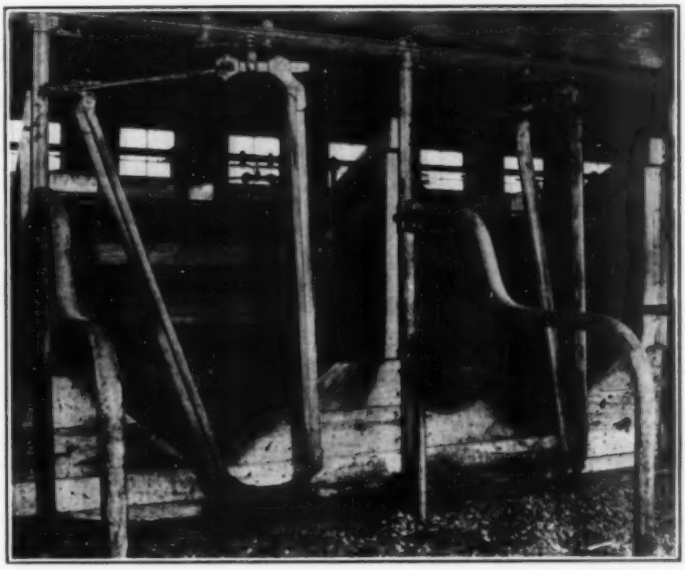
Considerable difficulty has been experienced with losses of feed when conducting feeding experiments with dairy animals. When the amount of feed is restricted the head of the animal may be closely confined for a sufficiently long time to allow the animal to eat and by so doing insure against any considerable loss of feed; however, when the animal is fed to the limit of her capacity, eating requires considerable time and she must have enough freedom to insure comfort, therefore losses of feed are difficult to prevent.



The accompanying diagram shows a manger that has proved satisfactory in use under the latter conditions. The mangers were built in sections long enough to provide individual mangers for three stalls. These were built and then set in place before the stalls. Two features distinguish these mangers from those that have been used commonly heretofore. First, a swinging rack or frame is suspended from a horizontal rod thirteen inches from the

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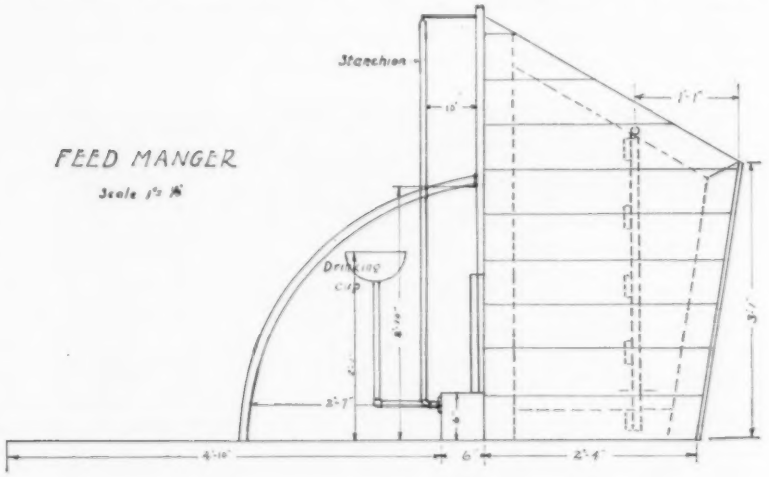
[1] Acknowledgment is gratefully made to Mr. A. G. Foster of the Agricultural Engineering Department for the accompanying sketch.

extreme front of the manger and high enough so that it will swing clear of the floor. The frame is made up of 1″ × 3″ oak boards with the horizontal boards six inches apart. The hay is placed in the manger ahead of the frame and must be pulled through between the horizontals a mouthful at a time. The frame prevents the animals from throwing the hay over the front of the manger and is easily swung to the rear to clean the manger. Only one animal of twelve using the mangers draws enough hay through the frame to scatter appreciable quantities in the front part of the stall around her front feet, and even then the scattered material contains no leaves which drop in the manger. Two by six planks nailed to the manger divisions above the




concrete curbing are notched to form a V before the stanchion so that the cow may lie down comfortably with her head in the manger. The amount of hay strewn in the stall is reduced by having the rear of the manger built up higher. The higher rear manger partition also prevents the frame from swinging backward too far. The watering cups are located behind the manger and under the stall division, thus preventing spillage of water on refused feed which must be weighed back. The stanchions which are in use here may be adjusted according to the length of the animals to align the animals with the gutter. These must be adjusted to the extreme rear to allow the stanchion to swing freely behind the rear manger partition, if the cows are stabled for long periods of time.

These inexpensive mangers have largely eliminated experimental error due to losses of hay.

# FEED UNITS FOR LACTATION, WORKING MAINTENANCE, AND GAIN IN LIVE WEIGHT IN DANISH DAIRY COWS

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The Agricultural Experiment Station at Copenhagen, Denmark, has published (1) the results of an extensive series of feeding experiments, conducted on a number of privately owned farms, to ascertain the effect of light to heavy feeding on milk yield. The plane of feeding was varied with respect to total feed units with total protein constant, and with respect to total protein with total feed units constant. In general these experiments were planned, using the feeding standard, $FU = .4FCM + (1.5 + .005W) + 4\Delta W$, as a guide.[1]

The feed intake is reckoned in the Danish work in terms of feed units. One feed unit is the equivalent of one kilogram of barley. In American units we may say one feed unit = 1.72 pounds of digestible nutrients, and one feed unit per kilogram (FCM, etc.) = .78 pounds of digestible nutrients per pound (FCM, etc.).

The Danish feeding standard given above has three components: $FU' = .4FCM$; $FU'' = 1.5 + .005W$; $FU''' = 4\Delta W$. The $FU''$ term is of special interest. It practically places the feed of working maintenance as proportional to the 2/3 power of live weight. The following numerical example will serve to show this:

| | | | | | |
|---|---|---|---|---|---|
| $W =$ | 400 | 450 | 500 | 550 | 600 |
| $FU'' = 1.5 + .005W =$ | 3.50 | 3.75 | 4.00 | 4.25 | 4.50 |
| $FU'' = .0635W^{2/3} =$ | 3.45 | 3.73 | 4.00 | 4.26 | 4.52 |

Thus, within the live weight range of its intended application the working maintenance standard is proportional to the 2/3 power of live weight.

## PURPOSE OF THIS PAPER AND RESULTS

It is proposed to apply the equation,

$$FU = aFCM + bW^c + d\Delta W \qquad (2)$$

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[1] Symbols are used (except as noted) to apply to each experimental period for each cow, as follows:

- FU = nutrients intake, feed units per day.
- FU′ = nutrients apportioned to lactation, feed units.
- FU″ = nutrients apportioned to maintenance, feed units per day.
- FU‴ = nutrients apportioned to gain in weight, feed units.
- FCM = milk-energy yield, kilograms of 4 per cent milk per day.
- W = average live weight, kilograms.
- ΔW = gain in live weight, kilograms per day.
- n = number of cows or records.

to the data as given in Tables 15–40 of the Danish report. The published data include for each cow and each experimental period: the average feed intake in feed units per day; the average FCM yield in kilograms per day; the average live weight in kilograms (average of initial and final live weights); the average gain or loss in live weight in kilograms per day.

Equation (2) is fitted to these observations according to the method of

TABLE 1

*Feed units apportioned to lactation, working maintenance, and live-weight gain. Records of Red Danish cows from Royal Veterinary and Agricultural College, Copenhagen, in groups of 10 or 20. (See footnote, page 645, for explanation of symbols)*

| Group No. | Sign of $\Delta W$ | n | Live-weight limits, kg. | W | $FU' = aFCM$ a | $FU'' = bW$ 1000 b | $FU''' = d\Delta W$ d |
|---|---|---|---|---|---|---|---|
| 1 | − | 10 | 381–418 | 407.1 | .4993 | 5.94 | 1.536 |
| 2 | + | 20 | 396–423 | 413.4 | .2850 | 10.56 | .980 |
| 3 | − | 10 | 420–439 | 430.5 | .6820 | 1.76 | 3.043 |
| 4 | + | 20 | 425–438 | 432.8 | .3168 | 12.29 | 1.593 |
| 5 | − | 10 | 439–446 | 442.2 | .5712 | 3.58 | .053 |
| 6 | + | 20 | 439–447 | 443.3 | .4590 | 6.70 | 4.060 |
| 7 | − | 10 | 446–450 | 448.2 | .3480 | 10.68 | 2.158 |
| 8 | + | 20 | 447–460 | 453.4 | .2671 | 12.64 | .246 |
| 9 | − | 10 | 451–460 | 453.4 | .3397 | 10.58 | .186 |
| 10 | − | 10 | 460–465 | 462.8 | .4556 | 7.35 | .508 |
| 11 | + | 20 | 460–466 | 464.1 | .5078 | 5.73 | 1.548 |
| 12 | − | 10 | 466–468 | 467.1 | .3661 | 9.31 | 1.085 |
| 13 | + | 20 | 466–471 | 469.2 | .4777 | 6.24 | 1.368 |
| 14 | − | 10 | 469–474 | 471.2 | .6615 | − .17 | − 1.866 |
| 15 | + | 20 | 472–476 | 473.4 | .3839 | 9.08 | 1.241 |
| 16 | − | 10 | 475–481 | 477.5 | .4332 | 7.06 | − .556 |
| 17 | + | 20 | 476–481 | 478.2 | .5656 | 5.15 | − .910 |
| 18 | − | 10 | 482–486 | 483.6 | .3030 | 10.09 | .480 |
| 19 | + | 20 | 481–489 | 484.4 | .5501 | 4.76 | .003 |
| 20 | − | 10 | 487–493 | 489.7 | .5419 | 7.21 | 1.104 |
| 21 | + | 20 | 489–495 | 492.3 | .5346 | 4.93 | .698 |
| 22 | − | 10 | 494–499 | 496.5 | .5082 | 6.45 | 5.573 |
| 23 | + | 27 | 496–503 | 499.7 | .4771 | 6.48 | .480 |
| 24 | − | 10 | 500–505 | 501.6 | .3904 | 7.81 | − 2.780 |
| 25 | + | 20 | 503–509 | 505.9 | .4045 | 8.22 | .653 |
| 26 | − | 10 | 505–513 | 509.8 | .4271 | 8.40 | 2.757 |
| 27 | + | 20 | 509–513 | 511.1 | .5119 | 5.84 | − .030 |
| 28 | − | 10 | 513–518 | 515.2 | .4411 | 7.26 | − .439 |
| 29 | + | 20 | 513–519 | 515.8 | .4127 | 8.36 | − .192 |
| 30 | + | 20 | 519–526 | 522.5 | .5527 | 4.32 | 2.577 |
| 31 | − | 10 | 518–527 | 523.7 | .4112 | 7.04 | − 1.343 |
| 32 | − | 10 | 528–532 | 529.5 | .5408 | 3.83 | − .310 |
| 33 | + | 20 | 526–533 | 529.6 | .4878 | 5.85 | .101 |
| 34 | + | 20 | 533–540 | 536.6 | .4635 | 6.98 | − .706 |
| 35 | − | 10 | 533–541 | 537.4 | .5151 | 5.62 | 1.805 |
| 36 | + | 20 | 540–551 | 545.6 | .4638 | 5.55 | 3.185 |
| 37 | − | 10 | 542–550 | 546.0 | .3492 | 9.07 | − 2.625 |
| 38 | + | 20 | 551–557 | 554.0 | .4463 | 6.76 | 1.060 |
| 39 | − | 10 | 551–568 | 558.3 | .4911 | 5.45 | − .194 |
| 40 | + | 20 | 557–565 | 561.1 | .3904 | 8.92 | − 1.159 |
| 41 | + | 20 | 566–590 | 575.6 | .3545 | 9.72 | .192 |
| 42 | − | 10 | 573–595 | 583.0 | .4624 | 6.95 | 1.252 |
| 43 | + | 20 | 590–674 | 613.7 | .5134 | 6.25 | − .903 |
| 44 | − | 9 | 595–642 | 613.8 | .2644 | 11.02 | 2.554 |

the preceding paper (2). The $+\Delta W$ records (cows with final live weight equal to or greater than initial live weight, $n = 447$) are arranged in order by W and divided into groups by successive 20's. The $-\Delta W$ records (cows with final live weight less than initial live weight, $n = 219$) are arranged in order by W and divided into groups by successive 10's. Each of these groups of records is fitted with the equation

$$FU = aFCM + K + d\Delta W \quad (1)$$

In equation (1) K represents $bW^c$ of equation (2). Table 1 gives the constants of equation (1) for each group, but K is given, in the FU″ column, as 1000K/W. Figure 1 shows 1000K/W plotted against W. The correlation between the two is $r = -.00 \pm .10$. There is no need to fit $K = bW^c$, for this zero correlation indicates that $c = 1$ in equation (2). The a, b, and d constants of equation (2) are taken to be, respectively, the average of the a,[2] b, and d values of Table 1. This gives

$$FU = .451FCM + .00713W + .68\Delta W \quad (3)$$

## DISCUSSION

It is of interest to compare equation (3), representing Red Danish cows in farm herds in Denmark, with the corresponding equation representing Guernsey, Holstein, and Jersey cows in Experiment Station herds in the United States (2). Equation (3) may be converted to terms of digestible nutrients and pounds by substituting DN for FU and multiplying through on the right by .78.

Comparison of the feeding standards, indicated by the Danish and American data, follows:

$$\text{(Danish)} \quad DN = .35FCM + .006W \quad (4)$$

$$\text{(American)} \quad DN = .28FCM + .009W \quad (5)$$

in which all terms are expressed in pounds (instead of kilograms). According to these results the Danish cow, as compared with the American, requires $\frac{1}{4}$ more digestible feed energy for lactation to produce a unit of milk energy, but $\frac{1}{3}$ less feed for maintenance per unit live weight. A difference of this magnitude, if real, commands attention.

Can it be that the Red Danish cow is more sluggish and expends less energy in muscular and general body activity, thereby reducing the energy cost of maintenance? (The Danish data include ages from 2.56 years to 14.32 years, with one cow 24 years old, while in the American data cows under 5 years of age are excluded.) If we could substitute .006W for .009W in equation (5) it would mean a saving of 19 per cent in the overall feed cost of producing milk in the case of a 1000-pound cow giving 25 pounds of 4 per cent milk per day.

[2] The correlation between a and W of Table 1 is $r = -.06 \pm .10$, and the coefficient of regression of a on W is $-.00011 \pm .00019$.

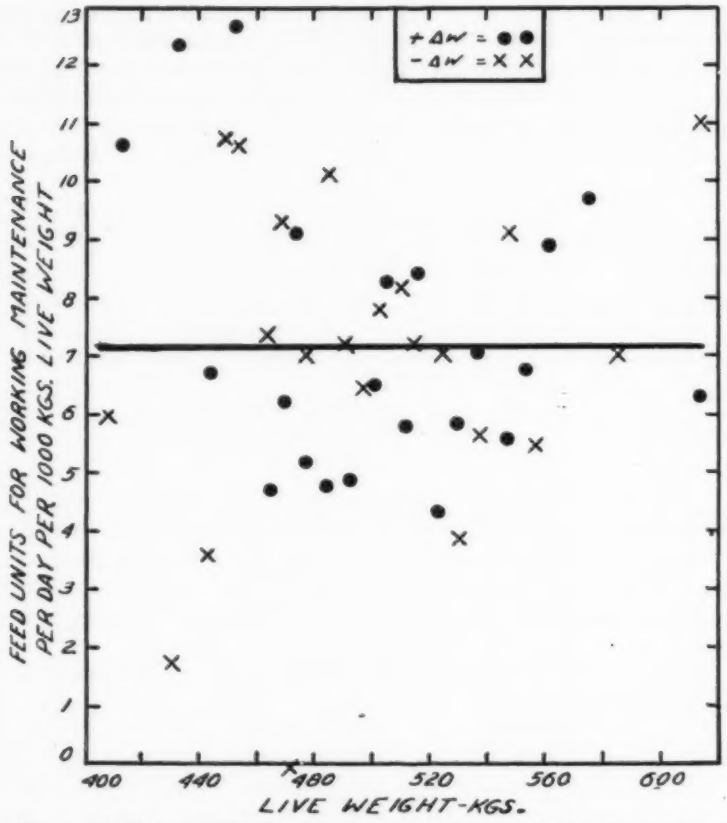


FIG. 1. Relation of working maintenance per unit live weight to live weight, from Table 1. The equation of the curve is $y = 7.13$, the correlation between x and y being $r = -.0049$.

Can it be that the Red Danish cow is not so highly developed as a dairy cow, and the mammary gland expends more energy to produce a unit of milk energy? Records of Red Danish cows show little or no relation between size of cow and amount of milk yield, while in American cows there is a decided relation, approaching direct proportionality in some cases. Any breed of cows that fails to show a relation between size and yield cannot be considered fully developed from a milking standpoint. That is, the activity in milk secretion has not progressed to a point where it taxes the strength of the cow.

Can it be that the difference between equations (4) and (5) is due to the

use of inadequate data or methods? Some of the limitations in this regard have been previously mentioned (2, 3). As the case stands it seems that feeding standards for cows in milk need to be adapted to the particular breed or kind of cow with which we are dealing. In practice the feeding standard affords the basis of formulating a trial ration. Adjustment may have to be made for the individual cow, according to her response in milk yield and gain in live weight. It is evident that while $\Delta W$ and $d\Delta W$, as used in the equations, are small in magnitude they may be large in physiological significance. Note the prevalence of minus d's in Table 1 and their drift to the larger W's. Undoubtedly more trustworthy results could be obtained from the present method of analysis if the experiments were designed for the purpose. Nevertheless, the data and analysis, as they stand, warrant tentative conclusions.

## SUMMARY AND CONCLUSIONS

Six hundred sixty-six records of Red Danish cows on farms in Denmark are analyzed to apportion the nutrients consumed between lactation, working maintenance, and gain in live weight.

A feeding standard derived from the records disagrees in some respects with the standard which guided the feeding of the cows. Notably, the standard used assigns nutrients for working maintenance proportional to the $\frac{2}{3}$ power of live weight, while the present analysis of the records shows the nutrients for working maintenance are proportional to live weight.

The present standard from records of Red Danish cows, compared with the standard similarly derived from records of Guernsey, Holstein, and Jersey cows in Experiment Station herds in the United States, shows a great difference, as follows:

(Danish) ..... $DN = .35FCM + .006W$
(American) ..... $DN = .28FCM + .009W$

where DN is digestible nutrients consumed, pounds per day; FCM is milk energy yield, pounds of 4 per cent milk per day; W is live weight of cow, pounds. It is tentatively concluded that the Red Danish cow is not so well developed as a milking cow, requiring more feed energy for lactation per unit of milk energy produced, but, on the other hand, is a more sluggish cow requiring less feed energy for working maintenance per unit live weight. A feeding standard for cows in milk needs to be adapted to the particular breed or kind of cows for which it is used.

The Danish and American data agree in indicating that working maintenance is proportional to live weight, and not to a fractional power of live weight.

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# THE USE OF RECORDS IN EVALUATING THE INHERITANCE OF COWS AND IN THE PROVING OF BULLS

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With the Herd Improvement Registry test of all the dairy breeds continually increasing and with the Dairy Herd Improvement Association program maintaining its popularity, there has been increasing attention devoted in recent years to lifetime production records. In some instances, national Breed Associations have granted special honor to cows that during their entire lifetimes, produced certain quantities of milk and butterfat. Cows that have produced one-hundred thousand pounds of milk in their lifetimes, often have been given special awards and in local associations and shows, liberal recognition has been bestowed upon lifetime champions. Frequently, special classes have been offered for "Ton" cows and for "Two Ton" cows, that is, cows which have produced a ton or two tons of butterfat during their lifetimes. With this increasing attention being given to lifetime production, the tendency has been in some instances to discount and discredit individual records.

There is no question but that any cow which has produced one or two tons of butterfat during her lifetime is deserving of recognition as she has undoubtedly been a profitable dairy animal. It is true that cumulative production indicates that a cow has been a financial asset to the herd. In view of this emphasis on lifetime yields, it seems that a study of the contribution such cows have actually made toward herd and breed improvement is needed. Is it possible that as a basis for genetic study, the use of lifetime averages tends to reduce variation and to distort to some extent the inferences that would be drawn from such data? With the high probability that over a period of years some uncontrollable factor will interfere with the producing ability of a cow, is there a tendency to introduce this environmental influence if average records are used? During the past decade, the results of much research have been published indicating that the production record of a cow considered alone is a poor measure of the cow's possible transmitting ability. Most of the publications on this subject have considered only one record.

The question now arises, is the average of two, three, four or more records any better index as to a cow's transmitting ability than is one record? There are also other related questions that are pertinent at this time. If dam and daughter comparisons are used in attempting to evaluate the transmitting ability of a bull, should the highest records of each dam and daughter be compared; or should the two year old records of the dam and daughter be

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compared; or should a comparison be made between the average of all the records completed by each dam and each daughter? The latter method is the one most frequently used in Dairy Herd Improvement Association work. Then, what is the correlation that exists between one record and another record made by the same cow? Does the first record completed by a cow give much indication as to what she will produce in subsequent lactations barring illness or accident? If a cow has completed several records, does the first lactation record or does the highest record give a better indication as to the lifetime production?

In an attempt to throw further light on these questions, the Register of Merit and Herd Improvement Registry records of Jersey cows have been studied. In analyzing the records, it was first attempted to determine the repeatability of records made by Jersey cows. There were 197 cows which had completed five or more 305 or 365 day Register of Merit records. First, each record completed by each cow was converted to a mature 365 day equivalent basis using the age conversion factors previously tabulated and published by the American Jersey Cattle Club. Then the correlation between the first and second records completed by each cow was determined. Similarly, the correlation coefficients were determined between the second and third, the third and fourth, and the fourth and fifth records for each cow. Next, a comparison was made between the first record completed by each cow and the average of the next four records. Likewise, correlations were tabulated between the first record completed and the average of all five records and lastly, the highest record of each cow was compared with the average of all

TABLE 1

*Correlation coefficients between records made by the same cow*
(197 cows with 5 or more R. of M. records used)

| Comparisons and correlations made | Coefficient of correlation | No. of + variations | No. of − variations | Av. + and − variation |
|---|---|---|---|---|
| Comparison of 1st R. of M. record with 2d record | +0.71 ± .024 | 65 | 132 | + 57 − 103 |
| Comparison of 2d R. of M. record with 3d record | +0.77 ± .020 | 109 | 88 | + 71 − 80 |
| Comparison of 3d R. of M. record with 4th record | +0.69 ± .025 | 99 | 98 | + 85 − 86 |
| Comparison of 4th R. of M. record with 5th record | +0.59 ± .031 | 98 | 99 | +102 − 94 |
| Comparison of 1st R. of M. record with average of next 4 records | +0.62 ± .030 | 72 | 125 | + 57 − 103 |
| Comparison of 1st R. of M. record with average of all 5 records | +0.75 ± .021 | 74 | 123 | + 46 − 86 |
| Comparison of highest R. of M. record with average of all 5 records | +0.92 ± .007 | 197 | 0 | + 99 − 0 |

five records. Also, the average variations were determined for each comparison. The results are shown in Table 1.

The results of the first four comparisons show that in comparing individual records, the greatest correlation exists between the second and third records completed. Also, the average variations are less between the second and third records. All of the coefficients of correlation are very good showing a relatively high degree of repeatability between normal records made by the same cow. The last three comparisons are significant. Less correlation existed between the first record completed by a cow and the average of the next four records, than between the first and second records. When the first record was correlated with the average of all five records, the correlation was still higher for, in this instance, the first record was included in making the average for the five records. The correlation between the highest record completed and the average of all five records is extremely high and indicates that the highest record completed by any cow gives a very good estimate as to what the lifetime average will be provided the cow is kept on test continuously and encounters no disease or misfortune. It should be mentioned that in 147 instances of the 197 cows used for analysis, the first Register of Merit records were begun at under three years of age, indicating first lactation records. In nearly all cases, the subsequent records were made in consecutive lactations.

Next, exactly the same comparisons were made using 166 cows that had finished five or more consecutive, complete Herd Test lactations. These results are shown in Table 2.

TABLE 2

*Correlation coefficients between consecutive Herd Test records made by the same cow*
(166 cows with 5 or more Herd Test records used)

| Comparisons and correlations made | Coefficient of correlation | No. of + variations | No. of − variations | Av. + and − variation |
|---|---|---|---|---|
| Comparison of 1st Herd Test record with 2d record | +0.78 ± .021 | 70 | 96 | +111 − 60 |
| Comparison of 2d Herd Test record with 3d record | +0.80 ± .019 | 89 | 77 | + 75 − 87 |
| Comparison of 3rd Herd Test record with 4th record | +0.75 ± .023 | 102 | 64 | + 98 − 54 |
| Comparison of 4th Herd Test record with 5th record | +0.83 ± .016 | 121 | 45 | + 78 − 76 |
| Comparison of 1st Herd Test record with av. of next 4 records | +0.80 ± .019 | 105 | 61 | + 93 − 49 |
| Comparison of 1st Herd Test record with av. of all 5 records | +0.88 ± .012 | 104 | 62 | + 74 − 39 |
| Comparison of highest Herd Test record with av. of all 5 records | +0.92 ± .008 | 166 | 0 | + 98 − 0 |

The correlation coefficients in this table differ just slightly from the similar comparisons made on the cows with Register of Merit records. In most instances, the correlation coefficients are a little higher than shown in Table 1. This result was not unexpected for most Herd Test records are made on a lower level of production than Register of Merit records, which naturally tends to reduce the variation from the individual records and this reduction in variation may tend to increase the correlations. It will be observed that all of the correlations are exceptionally good and that the highest record completed shows a remarkable correlation with the average of all five lactations.

The results thus far have shown that the highest record completed by a cow is a good indication of her potential lifetime production, barring accident, disease, or other misfortune. However, in addition to indicating the economic worth of a cow as a producer in the herd, production records are also used in the proving of sires and in estimating a cow's transmitting ability. The great lifetime producing cows with a number of records to their credit and high lifetime production totals, have been profitable dairy animals but it is important to learn their contribution to their progeny and descendants. Have they made any more contribution than cows which have completed only one or two high records? It is undoubtedly true that there are instances of cows having been injured physically, due to over feeding while making a record, and it is also true that some of the cows which have completed exceptionally high records have not been tested again. Consequently, in such instances, these cows are credited with only one record. In most cases, nothing is known as to why these cows were not tested again and not given the opportunity to see what they might have done during an entire lifetime. Sometimes, such cows have been held up to ridicule as having made no contribution at all to the breed, while other cows that have not been able to produce nearly as much in a single lactation, but which having been tested year after year and amassing fair lifetime yields, have been pointed to with pride.

It seemed worth while to study the transmitting ability of the lifetime production champions and also the transmitting ability of cows which for some reason had only been tested once but which had completed an exceptionally high yield. In the Jersey breed, there are 176 cows that have completed five or more 305 or 365 day Register of Merit records and which also have at least one officially tested daughter. This group was divided into two divisions. The first division of 87 cows with five or more records had lifetime productions of less than three-thousand pounds of butterfat. Two comparisons were made on this group. First, the lifetime production was divided by the number of lactations giving the average yield for each record. This average yield for the records completed by each cow was then compared with the average yields of the daughters' records. The average of all the records

completed by each dam was 485.51 pounds of fat and the average of all the daughters' records was found to be 558.26 pounds of fat. In the second comparison, the highest record completed by each of the dams was compared with the highest record completed by the daughters. When the highest record of each dam was selected and the average obtained for the 87 cows, it was found to be 590.52 pounds of fat. The highest records of the daughters when averaged was found to be 583.81 pounds of fat. In this analysis, it should be mentioned that the average production of all the mature (6 to 10 years) 365 day Register of Merit records that have ever been completed is 556.50 pounds of fat.

The second group consisted of 89 cows with five or more Register of Merit records but with lifetime totals exceeding 3,000 pounds of butterfat. All 89 cows had officially tested daughters. The same two comparisons were made on this group as with the first group, namely, the average of the dams' records was compared with the average of the daughters' records and then the highest record of each dam was compared with the highest records completed by the daughters. The average of all the dams' records was 622.27 pounds of fat and the average of all the records completed by the daughters was 612.07 pounds. When the highest record completed by each dam was selected and these high records averaged for the 89 dams, the result was 777.87 pounds of butterfat. This figure was then compared with the average of the highest records completed by all the tested daughters which was found to be 647.13 pounds of butterfat. It is obvious that the daughters of the cows with lifetime records of over three-thousand pounds of butterfat have exceeded the breed average considerably in production, while the daughters of the cows with lifetime records totalling less than three-thousand pounds of butterfat have just equalled the average for the breed.

It was then ascertained that to October 1st, 1932, a total of 219 cows had been tested just once for the Register of Merit and had completed a single record exceeding 740 pounds of butterfat. No information is available as to why these cows were never entered on test again. It may be that in some instances, the cows did not calve normally again, although it was ascertained that 115 or fifty-three per cent of these cows did calve immediately after the completion of their records and qualified for Class AA or Class AAA and in 172 instances or seventy-nine per cent, calves born after the completion of the record were registered from these cows. There were 118 or fifty-four per cent of the 219 cows with two or more registered progeny born after the dam completed her high record. It seems obvious that in most instances these cows were owned by breeders who did not follow a continuous year after year testing program as was the case with the owners of the preceding group of lifetime champions. This is indicated by the fact that only 88 of these cows with one record exceeding 740 pounds of butterfat have officially tested daughters. The records of these 88 cows were averaged and the result was

790.72 pounds of fat. It will be noted that this average is just slightly higher than the average of the highest records completed by each of the second group of great lifetime producers. Next, the records of the daughters of these 88 cows were studied and two tabulations made. First, all of the records completed by each daughter were averaged and the average was found to be 639.53 pounds of fat. In the second tabulation, the highest records of all the daughters were averaged and the result was 651.43 pounds of butterfat. These tabulations are all given in Table 3.

TABLE 3

*High lifetime record cows and high individual record cows and the records of their progeny*

| | Average of all records completed by each cow | Average of highest records completed by each cow | Average of all records completed by all daughters | Average of highest records completed by all daughters |
|---|---|---|---|---|
| 87 cows with 5 or more R. of M. records totalling less than 3000 lbs. of fat and having tested daughters | 485.51 | 590.52 | 558.26 | 583.81 |
| 89 cows with 5 or more R. of M. records totalling more than 3000 lbs. of fat and having tested daughters | 622.27 | 777.87 | 612.07 | 647.13 |
| 88 cows with only one record and that record above 740 lbs. fat, and having tested daughters | | 790.72 | 639.53 | 651.43 |

Of principal interest is the fact that the daughters of these cows with only one high record show a slightly higher yield than do the daughters of the cows with lifetime records exceeding three-thousand pounds of butterfat. Apparently the daughters of the cows that have completed only one extraordinarily high record have themselves produced as well or better than have the daughters of the cows which during their lifetimes have produced more than three-thousand pounds of butterfat.

Previous work by numerous investigators has shown that the correlation existing between a dam's record and the daughter's record is relatively low. Correlation coefficients between dam and daughter records as published by Gowen (1), Turner (2), Gifford and Turner (3), and Smith, Scott and Fowler (4), range between +0.259 and +0.42. The following two tables illustrate the relationship existing first, between the average records of the dams with the average of their daughters' records and second, between the highest record of each dam and the highest records of her daughters.

In both of the preceding tables the relationship seems to be about the same and while there is some correlation existing between the records of the dams and the records of the daughters, the variation in the yield of each group of

TABLE 4

*Comparison of average records of cows having 5 or more records with the average records of their tested daughters*

| Production divisions of dams | No. of comparisons | Av. yield of dams | Av. yield of daughters |
|---|---|---|---|
| 700 lbs. and over | 16 | 761 | 640 |
| 650 to 699 lbs. | 14 | 675 | 617 |
| 600 to 649 lbs. | 24 | 622 | 629 |
| 550 to 599 lbs. | 27 | 573 | 607 |
| 500 to 549 lbs. | 41 | 523 | 560 |
| 450 to 499 lbs. | 30 | 476 | 548 |
| 400 to 449 lbs. | 17 | 432 | 551 |
| Under 400 lbs. | 7 | 359 | 550 |
| Total and averages | 176 | 554 | 585 |

daughters was quite pronounced. This is best indicated by the fact that the coefficient of correlation between the highest records of the dams and the highest records of the daughters was found to be $+0.29 \pm .047$, while the correlation between the average records of the 176 dams and the average yield of their tested daughters was found to be $+0.30 \pm .046$. These correlations are most significant. While they are both quite low, they are practically the same and indicate that the highest record of a cow gives about as much information concerning a cow's possible transmitting ability for production to her

TABLE 5

*Comparison of highest records of cows having 5 or more records with the highest records of their tested daughters*

| Production divisions of dams | No. of comparisons | Av. yield of dams | Av. yield of daughters |
|---|---|---|---|
| 900 lbs. and over | 12 | 979 | 688 |
| 850 to 899 lbs. | 11 | 870 | 665 |
| 800 to 849 lbs. | 14 | 823 | 663 |
| 750 to 799 lbs. | 14 | 767 | 601 |
| 700 to 749 lbs. | 24 | 725 | 672 |
| 650 to 699 lbs. | 23 | 670 | 581 |
| 600 to 649 lbs. | 31 | 626 | 591 |
| 550 to 599 lbs. | 19 | 577 | 588 |
| 500 to 549 lbs. | 15 | 530 | 544 |
| Under 500 lbs. | 13 | 457 | 579 |
| Total and averages | 176 | 685 | 614 |

daughters, as does the average of a series of records completed during an entire lifetime.

An item of interest in this connection is that the 197 cows with five or more Register of Merit records have an average of 6.05 registered progeny per cow, to date. The 219 cows with only one high Register of Merit record have an average of 4.70 registered progeny each, to date. It is realized that in both cases, these averages of progeny are not complete for in many instances

calves are still being registered from these cows and also very often male calves are not registered. In addition, in a number of cases, calves may have died before being recorded.

As a supplement to the data already presented, a study was made of the first calf heifers of the breed which had completed exceptionally high records. Prior to 1933, a total of 318 heifers starting test at two years nine months or under, have completed a Register of Merit record in excess of 600 pounds of butterfat. Of these 318 high record first calf heifers, 172 completed second records and 70 have completed three or more records. The first and second records were compared and the correlation coefficient was found to be $+.55 \pm .036$. This correlation while good is somewhat lower than the correlations between the first and second records shown in Table 1 and Table 2. When the records were computed to maturity, the first records of the 172 cows averaged 890 pounds of fat and the second records averaged 833 pounds of fat. It was then determined that 127 of these high record first calf heifers have tested progeny. The records of the cows and the records of their progeny were converted to a mature yearly basis. When the highest record of each cow was compared with the highest record of the daughters for the entire group, the correlation coefficient was found to be $+0.30 \pm .055$. This correlation is in agreement with the previous correlations between the highest record of the lifetime dams and daughters and the average records of the lifetime dams and daughters. The following table also helps illustrate the relationship existing between the highest records of these cows compared with the highest records of their tested daughters.

TABLE 6

*Comparison of highest records of (high yielding) heifers with highest records of their tested daughters*

| Production divisions of dams | No. of comparisons | Av. yield of dams | Av. yield of daughters |
|---|---|---|---|
| 1000 lbs. and over | 22 | 1071 | 777 |
| 950 to 999 lbs. | 15 | 970 | 770 |
| 900 to 949 lbs. | 19 | 918 | 708 |
| 850 to 899 lbs. | 29 | 870 | 704 |
| 800 to 849 lbs. | 34 | 831 | 688 |
| Under 800 lbs. | 8 | 782 | 606 |
| Totals | 127 | 890 | 715 |

Twenty-eight of these high record heifers were the dams of "tested" bulls. The records of the twenty-eight dams averaged 957 pounds of fat and the records of the daughters of the twenty-eight sons averaged 636 pounds of fat. In the preceding group of cows with five or more records, nineteen were the dams of "tested" sons. The highest records of the dams averaged 864 pounds of fat and the sons' daughters' records averaged 627 pounds of

fat. The 317 high record first calf heifers have an average of 4.37 registered progeny each, to date, which is slightly less than the two preceding groups studied.

## SUMMARY

In summarizing the results of both phases of the investigation, it seems apparent that given the opportunity and barring illness or injury, a cow capable of completing one good record should be able to complete a number of lactations with good yields and thus finish a lifetime with a creditable total production. This is not in any sense an argument against continuous year after year testing. Continuous testing is needed to prove bulls at the earliest possible age. Several records are often needed on many cows to secure one complete lactation in which everything including health, feeding and management, and climatic conditions are fairly normal. Records made following abortions, attacks of bloat, milk fever and mastitis infection, do not give a true picture of a cow's ability at all. Neither are the records made in some sections of the drouth area during recent years, a fair measure of a cow's actual ability. Furthermore, only by continuous testing can a breeder tell definitely when a cow has ceased to be a profitable member of the herd.

Because of the necessity to assay the transmitting ability of bulls at the youngest possible age, it is impractical to compare lifetime records of daughters with the lifetime records of their dams. If we compare the average of several records on the dams with the first lactation records completed by the daughters, the results may be misleading. In selecting bulls, if the practice of comparing the highest record of the daughter with the highest record of the dam is used, no allowance is then made for the probability that the daughters will better their early records in later life and this method should improve the chance of a breeder being correct in selecting proved sires. In other words, an additional safeguard is furnished by insisting that the daughters of a bull in one or two trials produce as well or better than their dams were able to do in perhaps five or six trials.

If a cow has completed one record of 600 or 700 pounds of butterfat, she obviously possessed the inheritance to produce that amount in a lactation, unhampered by illness, poor management, or drouth conditions and consequently it seems that one record, and preferably the highest record, is suitable for evaluating the sire's ability and in trying to measure the cow's transmitting ability. Breeding operations will be seriously handicapped if breeders are forced to wait until cows have finished a series of four or five or more records, in order to obtain worth while information as to the sire's ability or the cow's own possible transmitting ability.

It also seems apparent from the data presented, that neither the highest record nor the average of several records gives a great deal of information

concerning the cow's transmitting ability as measured by the correlation with the daughter's production. To attempt to measure this, additional information is essential, such as the records of a cow's sisters and the records of her daughters. In a previous paper by the author (5), it was concluded that the record of a cow together with the records of her daughters and the records of her sisters did give a fair estimate concerning her transmitting ability.

Lifetime productions are largely influenced by longevity, opportunity, and perhaps to a certain extent, good fortune. Little if any data have been published concerning the inheritance of longevity. Unfortunately this is often not determined by nature. A high percentage of cows culled from the herds are removed due to disease infection. Is there any reason to believe that a cow, descending from a line of long-lived ancestors, is more immune to mastitis, Bangs' infection, etc., than is the daughter of a cow living only long enough to complete one or two lactations? Udder attachment is also another factor affecting the length of time cows remain in herds and it may be that some cows with a high inherited producing ability have not inherited a sufficiently strong udder attachment to keep the udder from breaking away and becoming pendulous. However, feeding and management may also be partly responsible for udder troubles. The inheritance of high milk producing ability, longevity, breeding efficiency, disease resistance and strength of udder attachments, all contribute to the end product of profitable lifetime production. Yet, it seems that these are separate problems in themselves and the selection of the highest record of an animal is the best index as to that animal's actual inherited production capacity under normal conditions.

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# FEED FLAVORS IN MILK AND MILK PRODUCTS

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The producer of milk is always confronted with the problem of preventing sour milk. With the increased consumption of milk and milk products has come the demand that milk not only be sweet but that it have a pleasing flavor. Milk containing an abnormal flavor is rejected by dealers and consumers. Dairymen are giving considerable attention to the prevention of losses due to sour milk. They too rarely recognize, however, that the production of milk containing objectionable flavors not due to souring is causing an annual loss probably greater than that from sour milk.

The fact that the feed consumed by the cow may be a contributing cause of abnormal flavors in milk has long been recognized. As early as 1829 William Harley (1) described a method for "preventing milk from tasting of turnips." He also observed, "It is chiefly common turnips and cabbages that give the strong taste to milk and butter." Many other early references are available dealing with the effect of feeds on the quality of milk. Almost without exception, in these early studies, quality was based on the chemical constituents of the milk. The effect of feeds on the flavor of milk was overlooked, or, if noted, dismissed with a sentence or two.

Although some work was reported prior to that reported by Gamble and Kelly (2), apparently it was the systematic study by the latter investigators on the effect of silage on the flavor and odor of milk that initiated recent interest in the subject. They reported a wide variation among individual normal cows in the flavor and odor of the milk produced. Cows receiving the same feed and care produced milk that ranged in flavor from pleasing to objectionable. Roadhouse, Regan, and Mead (3) confirmed the fact that there is a marked difference in the flavor of milk of individual animals and later Roadhouse and Koestler (4) reported on the causes of these variations in the flavor of milk from individual cows.

Gamble and Kelly (2) showed that in feeding corn silage before milking, when as little as 10 pounds was given at a feeding, the milk took on, through the body of the cow, a faint feed flavor and odor. As the quantity was increased to 30 pounds at a feeding, the degree of silage flavor and odor was likewise increased. This confirmed the work of Knisely (5), who reports that milk from cows fed corn silage has a more pronounced odor than milk from cows fed hay. King (6) also stated "It was demonstrated beyond

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*Editor's Note:* This is the first of a series of reviews by recognized authorities on subjects of interest to the Dairy Industry.

question that when silage is fed a short time before milking, a sweetish odor is imparted to milk."

Gamble and Kelly (2) showed further that when as little as 30 pounds of corn silage was fed daily, in two feedings immediately after milking, the milk showed a slight feed flavor and odor; and that when more than 40 pounds was fed, the milk carried a slight silage flavor and odor continuously. Henry and Morrison (7) report that as the silage-feeding period progressed the effect of the silage became less and less apparent in the milk. Gamble and Kelly (2) showed that this applied, however, only when less than 35 pounds was fed per cow per day; it was shown that when over 40 pounds was consumed, the sweetish feed flavor could always be detected. From their work with corn silage they concluded that: (1) When silage is fed 1 hour before milking its taint is discernible in the milk. (2) Not over 15 to 25 pounds of corn silage can be fed twice daily after milking without imparting a discernible flavor and odor to the milk. (3) Silage should be fed immediately after milking.

In experiments with alfalfa, sweetclover, and soybean silages Gamble and Kelly (2) showed that legume silages should also be fed only after milking and then in quantities of not more than 15 pounds to a feed twice daily if milk reasonably free from feed taints is to be obtained. In regard to soybean silage, Woll and Humphrey (8) stated that satisfactory dairy products could not be made when cows were fed this silage, and Woodward and McNulty (9) reported that silage made from clover, while palatable, has an objectionable odor necessitating care in feeding to avoid tainting the milk.

Russell (10) states: "As milk is exposed during the milking process, and very often after its withdrawal to an atmosphere that is liable to contain odors of an undesirable character, it is not surprising to note that it may thus contract flavors by direct absorption." Ritland (11) expressed the opinion that the flavor noted in milk of cows fed turnips is due entirely to the absorption by the milk of volatile ingredients of the turnips. Farrington (12) says, "It has repeatedly been proved that silage can be fed to dairy cows without tainting the milk, butter or cream, in the slightest, but unless certain precautions are taken to prevent this, the cream or butter may be so tainted with silage smell that many customers will refuse to use it. The success of feeding silage depends almost entirely upon the disposition of the man feeding it, to constantly keep the air in the stable free from silage smell."

As a result of trials in which silage was spread on the floor underneath two cows in a stable with the doors and windows tightly closed, thereby exaggerating barn-air saturation, Gamble and Kelly (2) showed that silage-tainted barn air may have some effect on the flavor and odor of milk under such extreme conditions, but concluded that the effect would be relatively small under average conditions.

They further showed that careful and prompt aeration of the warm milk will remove silage flavors and odors permanently, if the milk was only slightly tainted, and will reduce the degree of the silage flavors and odors if the taint was more pronounced. This is in agreement with Marshall (13), who stated, "Odors and taints resulting from aromatic foods, physiological processes, and disease processes may be greatly reduced permanently," by aeration.

Other facts brought out by Gamble and Kelly (2) were: (1) Feeding moderate quantities of corn silage after milking and prompt aeration of the milk may in some cases actually improve the flavor of milk that would otherwise have a flat or insipid taste. (2) While silage odors in the barn air have only a slight effect on the flavor and odor of milk, it is best to provide adequate ventilation and to practice other sanitary measures to insure the finest possible flavors. (3) The feeding of badly decomposed or moldy silage imparts undesirable flavors to milk. (4) Cream from silage-tainted milk possesses and retains silage flavors and odors to a greater extent than the milk from which it is taken. (5) Condensed milk made from silage-tainted milk has a less perceptible silage flavor and odor than the milk from which it is made.

Babcock (14–18) confirmed the work of Gamble and Kelly (2) in that he found: Feed flavors are more pronounced in the cream than in the milk from which the cream is taken. Proper aeration reduces strong off flavors and odors in milk caused by feeding highly flavored feeds, and some of the slight off flavors and odors may be eliminated. Even highly flavored feeds may be fed immediately after milking without seriously affecting the flavor of the milk produced at the next milking.

He showed that when fed to dairy cows 1 hour before milking, green alfalfa, cabbage, turnips, rape, and kale seriously affect the flavor and odor of milk. Green rye, green cowpeas, potatoes, dried beet pulp, and carrots affect milk only to a slight degree. Green corn, green oats and peas, green soybeans, pumpkins, and sugar beets have practically no effect on the flavor and odor of milk. When dairy cows were fed 1 hour before milking time and consumed 15 pounds twice daily of those feeds that were found to affect seriously the flavor of milk, objectionable flavors and odors were produced in the milk. Increasing the consumption of these feeds to 30 pounds twice daily greatly increased the intensity of the abnormal flavors and odors. When these feeds were fed in quantities up to 30 pounds twice daily immediately after milking, they had practically no effect on the flavor and odor of the milk produced at the next milking. In fact, in the case of green alfalfa, it was shown that changing the time of feeding from 1 hour before milking to 3 hours before milking, decreased the intensity of the abnormal flavor, and feeding 5 hours before milking practically eliminated it. On the other hand, large quantities of feeds like cabbage and turnips, even though fed immedi-

ately after milking, may at times slightly taint the flavor of the milk produced at the next milking. These taints, however, are slight and would seldom be noticed by the average consumer. Feeds that had only a slight effect when fed before milking had no detrimental effect when fed after milking.

In order to show more conclusively that feed flavors enter milk mainly through the body of the cow and to determine the time required for flavors to enter the milk, Babcock (19) conducted feeding experiments with garlic. This work showed that garlic flavor and odor can be detected in the milk when the milk samples are taken 1 minute after garlic is fed. The intensity of the garlic flavor increases as the time interval between feeding the garlic and taking the milk samples increases, until at 10 minutes a high degree of intensity is reached. Garlic flavor is present to a very objectionable degree in milk from cows that have consumed one-half pound of garlic 4 hours before milking. Milk drawn 7 hours after the cows consume one-half pound of garlic is practically free from garlic flavor. Strong garlic flavor is found in milk drawn 2 minutes after the cows inhale garlic odor for 10 minutes and practically disappears in 90 minutes after such inhalation. Garlic odor is readily perceived in samples of blood drawn 30 minutes after the cows are fed 2 pounds of garlic tops and strong garlic odor is present in the blood drawn 45 minutes after such feeding, indicating that the flavor is transmitted by the blood to the udder.

His work with bitterweed (20) further confirmed the fact that flavors enter milk mainly through the body of the cow. This weed is frequently found in southern pastures and, although it is practically odorless, it imparts its flavor to the milk when the cows eat it. Work with this weed also showed it to be an exception to the usual rule "that feed flavors are more pronounced in cream than in the milk from which the cream is taken," the flavor produced by bitterweed being more pronounced in skim milk than in whole milk and much less pronounced in the cream than in the skim milk. It further showed that there also may be exceptions to the rule that "feed flavors are not imparted to milk except for a few hours after feeding." When cows consume 10 pounds of bitterweed the flavor is present in the milk produced 24 hours later, but milk produced 27 hours later is practically free from a bitter flavor.

Babcock (21) summarizes his work by stating: "Proper methods of feeding are essential to the production of palatable milk. In most cases feed flavors are not imparted to milk except for a few hours after feeding. For this reason dairy cows should be given highly flavored feeds immediately after milking, never just before. When consumed in large quantities, feeds such as cabbage, which has an unusually strong flavor and odor, occasionally affect the quality of milk for 12 hours after feeding; but the intensity of the flavor has usually decreased to such an extent that it would not be noticed by the average consumer." He further states: "Proper aeration and cooling reduce strong feed flavors and odors and sometimes eliminate slight flavors

and odors. Therefore, when the practice of feeding immediately after milking is followed by proper aeration of the milk, most highly flavored feeds will not make the milk unpalatable."

Some of the feeds studied by Babcock (14–18) are mentioned in earlier literature. Vandenhoydonck (22) reports a case in which the cause of a bitter flavor in milk was located in the feeding of Swedish turnips which had been washed in foul ditch water. Dammann (23) says "Bitterness in milk is often due to feedstuffs such as oat straw, turnip roots, cabbage, rapeseed cake, wormwood." Dean (24) reports feeding cows 3 pecks (41 pounds) of turnips per day with the result that a slight taint was noted in the milk. When 4 pecks (55 pounds) were fed, the milk had a decided taste of turnips. Pasteurization and added starter prevented this taste from being carried to the butter. He also reported that the flavor of butter was slightly better from mixed feed than from silage feed. Lindsey, Holland, and Smith (25) report that the feeding of dried distillers' grains or brewers' dried grain in quantities of from 3 to 4 pounds per cow per day did not affect the flavor of the milk, and regarding the feeding of beet pulp Reece (26) reports that the milk showed no uncommon flavor of any kind when 10 pounds per head per day of the best pulp slices were being fed to cows at 4 important English agricultural colleges.

The results obtained by Gamble and Kelly (2) and by Babcock (14–21) have been confirmed and extended by other investigators. Davies (27) reported that the feeding of dried beet pulp sometimes causes a fishy or off-flavor in milk. Hening and Dahlberg (28) found no abnormal flavors due to feeding mangels or dried beet pulp and at the same time concluded that these feeds in no way prevented or increased the susceptibility of milk to the development of oxidized flavor.

Roadhouse and Henderson (29) state that "full rations of alfalfa hay, green alfalfa, clover hay, or corn silage fed 1 to 2 hours before milking produced strong, undesirable feed flavors and odors. As the interval between feeding and milking increased, the intensity of the feed flavors decreased. When these feeds were withheld during the 5-hour interval before milking, objectionable feed flavors and odors were eliminated." These authors also found that when green barley, wild oats, foxtail, and filaree were fed to cows 2 hours before milking, in quantities required for satisfactory nutrition and as a sole source of roughage, undesirable feed flavors varying from slight to strong were imparted to the milk in every instance. Tame oat hay gave only slight after-flavor in milk when 8 to 9 pounds was fed to cows 2 hours before milking. When fed in a mixture with 7 pounds of alfalfa hay, it did not modify the intensity of the alfalfa flavor. Improperly cured hay having a musty odor transmitted a musty flavor to milk.

Studying the concentrates, these same investigators state "The usual concentrate feeds—rolled barley, coconut meal, soybean meal, cottonseed

meal, wheat bran, and dried beet pulp—when fed 1 or 2 hours before milking, in quantities used by the average commercial dairyman, did not give milk sufficient flavor to make it undesirable to the average consumer. Rolled barley and beet pulp, however, fed alone in 5-pound quantities or more, 1 and 2 hours before milking, gave either a detectable flavor or after-flavor; but the judges believed that these would not be noticed in cold milk by the average consumer. Wheat bran seemed to improve the flavor of the milk when fed in 5½ to 7 pound quantities 1 hour before milking. It gave more flavor to the milk than was present in the control samples, and the flavor was reported as pleasing."

In a study to determine the rate at which the juice of the alfalfa plant made its appearance as a feed flavor in the milk, Roadhouse and Henderson (30) concluded: "Feed flavor appears in milk 20 minutes after the ingestion of flavor-producing materials in liquid form. The most pronounced feed flavor was present in the milk drawn 45 to 60 minutes after drenching."

These same investigators (Roadhouse and Henderson) (31) found that when cows were fed alfalfa hay as roughage immediately after milking or were given access to alfalfa pasture both day and night for the entire interval between milkings, they did not consume sufficient feed during the last 5 hours before milking to seriously affect the flavor of the milk. When they were given access to the pasture only, during the interval between morning and evening milkings, they consumed sufficient feed during the 5-hour interval before milking to cause an objectionable feed flavor in the milk. Under these conditions they recommend that the cows be removed from the pasture 4 or 5 hours before milking if feed flavor in milk is to be entirely avoided. They also recommend that if large amounts of corn silage are used in the ration it be fed after milking.

Lucas (32) stated "Alfalfa hay gives to milk a rather pronounced flavor but it is objected to only by a very few people." Weaver, Kuhlman, and Fouts (33) concluded from their work with alfalfa hay that: "Alfalfa hay fed less than four hours before milking has a pronounced effect on milk flavor. This effect is observed even when the interval between feeding and milking is only one-half hour. The two-hour interval causes the most serious flavor in the milk. If the hay is fed as long as four hours before milking the flavor is entirely eliminated with some cows. With other cows it is so reduced as to be scarcely discernible. Aeration of the milk removes some of the flavor but does not entirely eliminate it. Cooling seems to be ineffective and the effect of alfalfa hay is far more serious than that of darso silage."

The important part which feeds play in the flavor of milk has been further exemplified by Weaver, Fouts, and McGilliard (34). These investigators have shown that feed flavors are the most prevalent of the numerous flavor defects encountered in milk.

SUMMARY

The investigators on the effect of feeds on the flavor and odor of milk have shown that:

Many feeds impart their flavor to milk, the intensity of the imparted flavor depending upon the character of the feed, quantity consumed, and the time the feed is consumed in relation to the time of milking.

Feed flavors enter milk mainly through the body of the cow and in most cases these flavors are not imparted to milk except for a few hours after feeding.

Strong feed flavors are reduced in intensity and slight flavors may be eliminated by proper aeration.

Highly flavored feeds should be fed immediately after, never just before, milking.

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## American Dairy Science Association Announcements

### HUBERT EVERETT VAN NORMAN

JANUARY 30, 1872–JULY 28, 1938

Hubert Everett VanNorman, a professor of Dairy Husbandry and a prominent executive in educational and industrial institutions, died in Chicago, Illinois, on July 28, 1938.

Few men who have started their careers in the classroom and held prominent executive positions in educational institutions have been able to devote as much time to leadership in the dairy industry. He was reared on a dairy farm and with that background he had the interests of the dairy farmer at heart. During the years he was connected with educational work, he would turn aside his collegiate duties at any time to speak to dairy gatherings or attend dairy industry meetings in which he always took a prominent part. He was a clear, inspiring speaker. This quality and his broad experience in the dairy industry led to the continual demand for his services by dairy organizations. He once remarked that his greatest ability seemed to be as a speaker and a starter of new enterprises.

Dr. VanNorman was born at Tillsonburg, Canada, and came to the United States in 1880. He was graduated from the Michigan Agricultural College in 1897 and served as assistant buttermaker during his college course. After graduation he accepted a position at Purdue University as farm superintendent and instructor in dairying and was advanced to Chief of the dairy department in 1902, which position he held for four years. While at Purdue, he served for seven years as Secretary of the Indiana Dairy Association. In 1905 he became Professor of Dairy Husbandry at the Pennsylvania State College and was Head of the Department until 1913 when he resigned to accept a position with the University of California as Professor of Dairy Management, Vice-director of the Agricultural Experiment Station and Dean of the University Farm School.

While at Pennsylvania State College, Dr. VanNorman was active in improving the College instruction and was the author of the text book "First Lessons in Dairying." During these years he took a prominent part in state and national dairy association affairs and served as President of the Pennsylvania Dairy Union, secretary of the Agricultural Federation of Pennsylvania and Vice-President of the National Dairy Show in 1907–8. He was secretary and manager of the National Dairy Show for two years and finally president in 1911, which honor he held until 1922. While president of the National Dairy Show, Dr. VanNorman contributed much to the progress of dairying and the dairy industry. His speaking ability and dignity on the speaking platform brought him before many of the industry conventions and he held the dairy cattle equipment and machinery organizations together for

many years in a unified Dairy Exposition. During these years he served also as a director of the National Dairy Council and he was a charter member of the American Dairy Science Association. Although Dean VanNorman's duties were arduous in California in developing a recently established school of agriculture, he found time to attend meetings of the directors of the National Dairy Show and to spend a week at the Show to fulfill his responsibilities as president.

In 1921 plans were being made in Washington to invite the World's Dairy Congress to meet in the United States. Dean VanNorman was asked to serve as organizer and manager of the Congress. This important undertaking required the services of a man of ability in leadership who was well known to the dairy industry, and Dr. VanNorman was a happy selection for this important position. To assure representation of European countries at the Congress, Dr. VanNorman visited many countries in Europe and extended personal invitations. The Congress which was held in Washington, Philadelphia, and Syracuse in 1923, was splendidly organized and carried out. At the close of the Congress at Syracuse, the University of Syracuse conferred upon Dean VanNorman the honorary degree of Doctor of Laws.

In 1925 he was selected to organize the American Dry Milk Institute and he became its first president. In 1929 he resigned to become director of research for the Borden Company, which post he in 1903 left to take charge of the dairy industry exhibit at the Century of Progress Exposition in Chicago. At the close of the exposition Dr. VanNorman was Director of Development and Education for the Chicago Mercantile Exchange.

Those who knew Dr. VanNorman as a close personal friend, and who had been a guest in his home, realized his cordial and lovable nature.

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# ABSTRACTS OF LITERATURE

## BACTERIOLOGY

**474. Prevalence and Classification of Hemolytic Streptococci in Pasteurized Milk.** LAWRENCE W. SLANETZ, New Hampshire Agric. Exper. Sta., Durham, N. H. Tech. Bull. 70, January, 1938.

Routine analysis of the bacterial content of various samples of milk indicated that large numbers of weakly hemolytic streptococci were often present. In the present study an attempt was made to develop suitable methods and media for the detection and isolation of these streptococci and to determine their prevalence in pasteurized milk, their origin, and their identity.

These weakly hemolytic streptococci were absent in the pasteurized milk from only two of the nine dairies studied. Counts ranged from 200 to 270,000 per cc., and in nearly all cases were greater than the standard plate counts.

Sheep blood agar proved best suited for the detection and isolation of these bacteria. No apparent growth occurred on standard meat extract agar. Studies indicated the presence of the hemolytic streptococci in the raw milk before it reached the dairies, principally due to utensils which were not cleaned and sterilized thoroughly.

Sixty strains, classified into five groups, were identified and studied in detail. All were able to resist pasteurization temperatures and to produce colonies of the alpha prime type on blood agar.

Large numbers of these streptococci in milk are undesirable, and methods should be used for their detection and elimination. K.S.M.

**475. Induced O/R Potentials, Rates of Growth and the Volatile Acid Production of Lactic Acid Bacteria in Milk.** J. G. DAVIS, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. Dairy Research *9:* 85, 1938.

The abilities of type cultures of lactic acid bacteria to reduce five O/R indicators (methylene blue, Janus green, litmus, neutral red and safranine) were determined in plain milk and yeast dextrose milk. It is suggested that in some cases the reduction or non reduction of a dye may be used for identification purposes. Methylene blue, litmus and safranine may be of some value for this purpose. There was a marked correlation between rapidity of growth in milk, ability to reduce O/R dyes and the proportion of by-products. This relationship holds not only for the different groups and types, but also for variations in behavior observed in species kept under laboratory observation. It is suggested that rate of growth is fundamen-

tally related to the amount of by-products and hence presumably to flavor producing substances such as diacetyl and acetic acid. Thus in cheese ripening enforced slowness of growth may be as important as the presence of specific types. S.T.C.

**476. The Resazurin Test—A Preliminary Study.** J. M. FRAYER, Vt. Agric. Exper. Sta., Burlington, Vt. Bull. 435, June, 1938.

Preliminary trials were conducted with this test on samples of milk as delivered at creamery receiving stations and of individual cows' milks, drawn as aseptically as possible. Comparisons were made with the methylene blue reduction test and with plate and cell counts. The degree of dependability, the effect of variation in dye concentration, and of light and cooling were also studied. All samples were tested using one milliliter of a .005 per cent solution of resazurin to 10 ml. of sample and one-hour incubation at 37 + 1° C. (98.6° F.).

The resazurin test:

1. Correlated poorly with the methylene blue reduction test, hardly at all with the plate count, and fairly well with the cell count of near-aseptically drawn milk.

2. Is sensitive to the presence of cells, to the presence and activity of bacteria, and extremely so to either strong sunlight or artificial light.

It further appears that:

3. Slight variations in dye concentration exert little effect upon the readings.

4. Cooling to and holding at low temperatures definitely retards reduction.

5. Supplementary microscopic examination is advisable.

6. Especial consideration should be given the selection of a point in the range of color changes as a deadline between samples needing and not needing further inspection.

7. The resazurin test has value if properly conducted and intelligently interpreted, but it will not likely supplant the methylene blue reduction test for testing raw milk, unless the microscope and microscopist are available to afford diagnostic assistance. J.M.F.

## CHEESE

**477. Alcohol-Glycerol Rennet Preparations in Cheese-Making.** J. G. DAVIS, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9:* 80, 1938.

Brine rennet and alcohol-glycerol rennet extracts were compared in bacterial content, in keeping quality and in suitability for use in cheese making.

Brine rennets were found to have a bacterial count as high as 100,000 per ml., whereas the alcohol-glycerol rennets were either sterile or had a very low count. The alcohol-glycerol rennets had superior keeping qualities to the brine rennets. Chemical analysis, bacteriological analysis and graders' reports failed to distinguish the alcohol-glycerol rennet cheese from the brine rennet cheese. S.T.C.

**478. Annatto as a Cheese Colour.** M. S. CARRIE, Laboratory of the New Zealand Cooperative Rennet Co., Ltd., Eltham, New Zealand. Jour. Dairy Research *9:* 72, 1938.

Standardization of annatto in aqueous solution was attacked as unsound, and it was recommended that standardization be on the basis of the depth of color produced in cheese itself. A paper color standard was suggested. S.T.C.

Other abstracts of interest are: 475, 476, 480, 481, 482, 507, 508, 509, 510, 511, 513, 514, 515, 516, 517.

## CHEMISTRY

**479. A Lipase (Tributyrinase) of Cows' Milk. I. Occurrence, Method of Estimation and Relationship of Lactation Cycle.** E. C. V. MATTICK AND H. D. KAY, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9:* 58, 1938.

Tributyrinase in milk was estimated by determining the amount of volatile acids produced in 6 hours at 37° C. (98° F.) in a reaction mixture typically consisting of 100 ml. M/10 sodium diethyl barbiturate, 0.5 ml. pure tributyrin, and 20 ml. milk.

An enzyme which hydrolyses tributyrin was found to be present in all samples of cows' milk examined. It is associated with the aqueous rather than the fatty portion of the milk. Its optimal range of activity is in the range of pH 8.2–8.7. It is rather more thermolabile than phosphatase.

Its concentration was found to vary considerably in the milk from different cows, and during the lactation cycle in milk from individual cows. It is highest in concentration in colostrum, then the concentration falls to a minimum at about 10 days, rising later to a figure intermediate between this minimum and the colostral value. It shows no sign of increase toward the end of the lactation period. S.T.C.

**480. The Protein Distribution in Normal and Abnormal Milk.** SAMUEL J. ROWLAND, Dept. of Agric. Chemistry, University of Reading, Reading, England. Jour. Dairy Research *9:* 47, 1938.

Using the method described in the previous paper the nitrogen distri-

bution in terms of casein, albumin, globulin, proteose-peptone and non-protein nitrogen was determined for a number of samples of normal milk, of milk from cows with mastitis, and of milk persistently low in solids-not-fat content.

The milk from cows with clinical mastitis was found to be low in solids-not-fat and characterized by a decreased content of casein and an increased content of albumin, globulin and proteose-peptone substances, particularly globulin. A "casein number" calculated by the formula: casein number = $\frac{\text{percentage of casein N}}{\text{percentage of total N}} \times 100$ was suggested as a method for detecting subclinical mastitis. The minimum figure for normal milk was found to be 77.0.

S.T.C.

**481. The Determination of the Nitrogen Distribution in Milk.** SAMUEL J. ROWLAND, Dept. of Agric. Chemistry, University of Reading, Reading, England. Jour. Dairy Research *9:* p. 42, 1938.

Details are given of a semi-micro Kjeldahl method for the determination of the total, casein, albumin, globulin, proteose-peptone and non protein nitrogen of milk. The method is said to be accurate, rapid and particularly suitable for the determination of the smaller nitrogen fractions. The various nitrogen fractions are separated by the procedures described in the preceding paper.

S.T.C.

**482. The Precipitation of the Proteins in Milk.** SAMUEL J. ROWLAND, Dept. of Agric. Chemistry, University of Reading, Reading, England. Jour. of Dairy Research *9:* p. 30, 1938.

Methods for the separation of the total protein, casein, albumin, globulin and proteose-peptone substances of milk are described.

Maximum precipitation of casein from milk samples of varying casein content was effected by the addition to 10 ml. of milk of about 80 ml. of water at 40° C. (104° F.) and 1.0 ml. of 10 per cent acetic solution followed, after 10 minutes, by 1.0 ml. of N sodium acetate solution.

For the determination of total protein the most complete separation was secured by diluting 10 ml. of milk to 50 ml. with 15 per cent trichloracetic acid at room temperature.

Separation of globulin is effected by saturation of the filtrate (neutralized to pH 6.–7.3) from the casein determination with magnesium sulfate.

Methods also are given for the precipitation of and separation of the albumin and proteose-peptone substances.

S.T.C.

## DISEASE

**483. The Hemolytic Streptococci of Milk.** J. M. SHERMAN AND C. F. NIVEN, Cornell University. J. Infect. Dis. *62:* p. 190, Mar.–Apr., 1938.

A study was made of a number of samples of raw and pasteurized commercial milks to determine the incidence of hemolytic streptococci and the number of kinds of species present, with an attempt to differentiate harmless types from those of possible sanitary significance. Broad-zone hemolytic types were the only ones considered. Only 8.5 per cent of the pasteurized milk samples contained hemolytic streptococci, while 18 per cent of the raw samples were positive.

On the basis of serological and physiological tests, six groups or species were recognized: *Streptococcus mastitidis* (Lancefield group B), the "animal pyogenes" (Lancefield group C), *Streptococcus durans* (Lancefield group D), and two other unidentified types.

The prevailing types of hemolytic streptococci in raw milk were found to be *Streptococcus mastitidis* and the "animal pyogenes"; the most common forms in pasteurized milk were *Streptococcus durans* and *Streptococcus zymogenes.* W.C.F.

**484. Brucellosis in Horses.** W. S. Stone, Experiment Station, N. Y. State Veterinary College, Ithaca, N. Y. Cornell Veterinarian *28:* p. 91, 1938.

The author reviews the literature and presents some data concerning brucellosis in horses. Agglutinins are found in apparently normal horses as well as those affected with fistulous withers and poll evil. Horses in contact with cattle have a higher incidence of brucellosis than those kept away from cattle or maintained in cities. Horses may be a factor in transmitting Bang's disease to cattle. There is evidence that undulant fever may be contracted from the discharge of brucella infected horses. J.F.

**485. Detection of Mastitis by the Bromthymol-Blue Test, Leucocyte Count, and the Microscopic Examination of Incubated Milk.** A. C. Fay, H. W. Cave, and F. W. Atkeson, Kansas Agricultural Experiment Station, Manhattan, Kansas. Cornell Veterinarian *28:* p. 40, 1938.

Readings of the bromthymol-blue test, the leucocyte count, and the microscopic examination of incubated milk for streptococci on repeated quarter milk samples of 114 cows are compared.

Long-chained streptococci were found in the incubated milk of 13 per cent of heifers in their first lactation period, 38 per cent of cows in their second lactation period and in increasingly high percentages in the groups in the later lactation periods. J.F.

**486. Age as a Factor in Susceptibility to Johne's Disease.** William A. Hagan, Department of Pathology and Bacteriology, N. Y. State Veterinary College, Ithaca, N. Y. Cornell Veterinarian *28:* p. 34, 1938.

This paper presents evidence to show that young calves are most susceptible to Johne's disease and that natural infections occur very early in life. No cases were developed naturally in the experimental herd by animals which were exposed after the fourth month of life. Even in artificial infection, using much larger doses than animals could possibly acquire naturally, no animal more than two years of age was successfully infected. The period of incubation in dosed cases runs from nine months to more than two years. Allergic tests show that many animals that have contracted the infection are able to throw it off, usually without showing any clinical evidence of the disease. J.F.

**487. Bovine Mastitis. III. A Comparison of the Bacteriological and Physiological Reactions of Normal and Mastitis Milk from Young Cows.** RALPH B. LITTLE, Department of Animal and Plant Pathology, The Rockefeller Institute for Medical Research, Princeton, N. J. Cornell Veterinarian *28:* p. 23, 1938.

Examinations of the foremilk of 8 first calf heifers before and after inoculation of the quarters with a double zone hemolytic streptococcus are compared. Plating of the milk in blood agar and the direct leucocyte count were found more efficient in detecting artificial infection than the hydrogen ion or chloride tests. J.F.

## FOOD VALUE OF DAIRY PRODUCTS

**488. Milk Important Source of a New Vitamin.** ANONYMOUS. Milk Dealer *27:* 10, p. 67, July, 1938.

According to a recent study of 73 South Carolina families, pellagra did not occur in families which used on the average two and one-fourth cups of milk per person per day, plus fruits, vegetables, and lean meat. Another study of 29 Florida families revealed that the important difference in the diets of pellagrous and non-pellagrous families was in the amount of milk consumed. C.J.B.

**489. The Effect of Commercial Sterilization on the Nutritive Value of Milk.** S. K. KON AND K. M. HENRY, National Institute for Research in Dairying, University of Reading, Shinfield, Nr. Reading, England, with the collaboration of E. W. IKIN, National Institute for Research in Dairying, University of Reading, A. E. GILLAM, University of Manchester, Manchester, England, and P. WHITE, University of Reading, Reading, England. Jour. of Dairy Research *9:* pp. 1–29, 1938.

I. *Introduction.* **S. K. Kon and K. M. Henry.**

For use in experiments to determine the effect of sterilization on the

nutritive value of milk, raw milk and commercially sterilized milk taken from the same original batch of milk were secured daily from a large processing plant. For sterilization the milk, after homogenization at 4000 pounds pressure, was heated in bottles to 230° F. and held for some time at this temperature before air cooling.

IIa. *Biological Value and Digestibility of the Proteins (Nitrogen) of Milk.* **K. M. Henry and S. K. Kon.**

Paired feeding experiments with rats indicated for raw milk a biological value of 84.3 and a true digestibility of 96.4, while for sterilized milk the figures were 79.1 and 95.3 respectively. It is suggested that the lowered biological value of sterilized milk may be due to partial destruction of cystine or methionine.

IIb. *A Note on the Effect of the Method of Feeding Dried Skimmed Milk on the Biological Value of Its Proteins.* **K. M. Henry, E. W. Ikin and S. K. Kon.**

No significant difference was found in the biological value of the proteins when spray dried skimmed milk was fed separately from or mixed with a basal "nitrogen free" diet.

III. *Effect on the Vitamin A and Carotene Content of Milk.* **A. E. Gillam, K. M. Henry, S. K. Kon, and P. White.**

Butterfat was obtained by ether extraction from eleven samples of raw milk and from eleven corresponding samples of sterilized milk. The vitamin A and carotene content was estimated by colorimetric (Levibond tintometer) and by spectrophotometric tests. The results showed that the effect of the heat treatment was negligible, neither method demonstrating a loss in vitamin A, while for carotene only the colorimetric method indicated a loss of about 2 pr cent.

IV. *Effect on the Vitamin B Complex, on Vitamin $B_1$ and on Vitamin $B_2$ (Flavin) of Milk.* **K. M. Henry and S. K. Kon.**

Based on the rate of growth of rats receiving various quantities of raw and commercially sterilized milk in addition to a diet deficient in vitamin $B_1$ it was calculated that about one-third of the vitamin $B_1$ originally present in milk was destroyed by sterilization. Sterilization appeared to have no adverse effect on vitamin $B_2$ (flavin). S.T.C.

## ICE CREAM

**490. Factors Influencing the Body and Texture of Ice Cream.** W. H. E. Reid, Dairy Dept., Univ. of Missouri, Columbia, Mo. Ice Cream Trade J. *34:* 5, p. 20, May, 1938.

The effect of various ingredients used in ice cream and the methods used in processing the mix on the body and texture of ice cream are discussed. W.H.M.

**491. Make Merchandise Men.** MALCOLM PARKS. Ice Cream Trade J. *34:* 5, p. 16, May, 1938.

The author states, "The ice cream business today is in a state of transition, retail trends are changing, new competitive threats have arisen and the emphasis is on service and co-operative effort by the dealer and company in meeting the conditions which have arisen. The dealer looks to his company to supply him with help, encouragement and ideas to combat the inroads of competition and conditions which he is unable to cope with alone. Companies are falling down on this job, largely because sheer apathy has conspired to maintain the old status quo." A Merchandising Counselors Data Chart to be used by sales managers in obtaining data on dealers to be used as a guide in their sales promotional work is presented. W.H.M.

**492. Who Sells Your Ice Cream for You?** IRVING B. WEBER, Sidwell Dairy Company, Iowa City, Iowa. Ice Cream Trade J. *34:* 5, p. 45, May, 1938.

The per cent of ice cream sold through different types of outlets for this manufacturer is as follows:

| Average Gallonage Rankings of Different Types of Accounts | My Gallonage Rankings for the Same Types |
|---|---|
| 1st—Drug Stores | 29% of total volume |
| 2nd—Eating Establishments | 50% of total volume |
| 3rd—Grocery Stores | 14% of total volume |
| 4th—Filling Stations | 4% of total volume |
| 5th—Beer Parlors | 2% of total volume |
| 6th—Miscellaneous Businesses | 2% of total volume |

In this instance the eating establishments are out-ranking the drug stores as an outlet for ice cream. W.H.M.

**493. Shrinkage—And How to Prevent It.** W. B. COMBS, Dairy Division, Univ. of Minn., St. Paul, Minn. Ice Cream Trade J. *34:* 4, p. 13, April, 1938.

Factors discussed which have an effect on shrinkage in ice cream are: overrun, storage and serving temperature, composition of the mix, and size of air cells as influenced by rate of freezing and hardening. Shrinkage can be reduced in factory filled package ice cream by filling the package as quickly as possible after the ice cream comes from the freezer, placing the package immediately in the hardening room, and storing the package at a low uniform temperature. W.H.M.

**494. How to Make Strawberry Ice Cream.** P. H. TRACY, Dairy Dept., Univ. of Illinois, Urbana, Ill. Ice Cream Trade J. *34:* 3, p. 17, March, 1938.

Good strawberry ice cream depends on (a) a good mix, (b) the proper selection of flavoring materials, (c) the combining of the fruit with the ice cream in the proper manner, and (d) correct freezing of the ice cream.

A fresh mix free from copper contamination should be used. Only enough color to give a pinkish shade and 15 to 20 per cent of a 2.5 to 1 pack of strawberries are suggested for good results. It is important to avoid diluting the mix with fruit to a point below the legal fat standard. By adding the fruit after the ice cream is drawn from the freezer the identity of the fruit particles can be maintained. Strawberry ice cream should be sold while fresh in order to minimize the development of a stale flavor in the product. W.H.M.

**495. Frozen Pack Fruits as Flavors for Ice Cream.** M. A. JOSLYN AND W. C. COLE, Dairy Division, Univ. of California, Davis, Calif. Ice Cream Trade J. *34:* 3, p. 16, March, 1938.

The authors state that frozen pack fruits generally prove as satisfactory as fresh fruits for flavoring ice cream. Fruit with a pronounced flavor, and not too high in tannic acid should be used. A 2 to 1 or 3 to 1 ratio of fruit to sugar is recommended for preserving the frozen fruit for ice cream. Fifteen to 20 per cent of fruit by weight should be used in the ice cream. It is desirable to have the fruit completely defrosted before use, and fruit in smaller size is preferable to the larger size particles. Discoloration of the fruit before use tends to injure the fruit's appearance and flavor, and a high fat content mix will tend to mask the fruit flavor. W.H.M.

**496. The Stabilization of Ice Cream with Sodium Alginate.** V. C. STEBNITZ AND H. H. SOMMER, Dept. of Dairy Husbandry, Univ. of Wisconsin, Madison. Ice Cream Trade J. *34:* 3, p. 14, March, 1938.

Sodium alginate, "Dariloid," was subjected to various tests and compared with gelatin as a stabilizer for ice cream. Two and one-half gallon experimental mixes were made and frozen in a 10 quart vertical brine freezer. The composition of the mixes used was sugar 16 per cent, fat 13 per cent, and serum solids 10 per cent. The method recommended for adding sodium alginate was to mix it in a little cold water, and add it to the mix at 160° F.

The authors summarized their results as follows: Ice cream mix, stabilized with sodium alginate ("Dariloid") was found to possess the following properties:

1. A higher pH and lower titratable acidity than an unstabilized mix. Three-tenths per cent "Dariloid" caused an average increase of 0.15 in the pH and a decrease in the titratable acidity of 0.015 per cent.
2. Slightly more color than gelatin mixes.
3. A uniform viscosity during aging. The viscosity of the freshly made mix was practically the same as the aged mix.

4. No tendency toward wheying-off.
5. No stabilizer sediment when the sodium alginate had been properly dissolved.
6. A maximum whipping ability immediately after being homogenized and cooled to 40° F.

Ice cream made from mix stabilized with sodium alginate ("Dariloid") was found to possess the following properties:

1. A color slightly lighter than gelatin ice cream.
2. Body and texture comparable to gelatin ice cream.
3. A "cleaner" flavor than gelatin ice cream.
4. Good water-holding capacity and resistance to the effects of heat shocking.
5. No tendency toward shrinkage.
6. Smooth, clean, melt-down appearance. W.H.M.

**497. Package Ice Cream.** KEN FORREST, Merchandising Editor, Ice Cream Field *32* (6) : pp. 7, 8, 10, June, 1938.

The author claims that unless ice cream manufacturers effectively merchandize packages and specialties, the home made dessert manufacturer "will take not only the business you hope to get, but a whole lot of business you already have."

He cites statistics from the International Association of Ice Cream Manufacturers that over 40% of the total volume sold was packages, cups and novelties.

One manufacturer is cited as successfully merchandising factory filled packages averaging only 69% overrun, in competition with cheaper merchandise.

According to the author "Your real competitor is not only your fellow ice cream manufacturer. It is the entire dessert industry, an industry that is using the power of consumer advertising to the tune of several million a year."

He emphasizes the importance of not only helping the dealer, but of using to advantage the advertising possibilities of factory filled packages. W.C.C.

**498. Liquid Sugar.** L. F. DARDONE, Production Manager, B. W. Dyer & Co., Ice Cream Field *32* (6) : p. 43, June, 1938.

The author states that economy in price and convenience are sufficient to justify ice cream manufacturers to use liquid sugar where available. Early supplies of liquid sugar were not well controlled technically hence their composition was not uniform or satisfactory. He states "Today it is possible to obtain liquid sugar, the solid content of which is the same composition as good granulated sugar and also with practically any invert content you may require up to completely inverted sugar." W.C.C.

**499. Stale Flavor Control.** K. G. WECKEL, Dairy Industry Dept., Univ. of Wisconsin. Ice Cream Field *32* (6) : pp. 13, 14, 17, 36, June, 1938.

The author discusses in a very general manner some of the common problems encountered with stale flavors in ice cream. He stresses the need of controlling the quality of ingredients used and suggests the use of certain anti-oxidants (avenex and a trypsin preparation). W.C.C.

Other abstracts of interest are: 479, 480, 488, 489, 507, 508, 509, 510, 511, 513, 514 and 516.

## MILK

**500. This Problem of Overlapping Ordinances.** J. W. YATES, General Laboratories, Philadelphia, Pa. Milk Dealer *27:* 9, pp. 98–101, June, 1938.

A discussion of the widespread non-uniformity in milk regulations. Examples of this non-uniformity are given. The author states that due to this non-uniformity much good milk is being rejected and does not have a free market, while other milk of inferior quality, in some instances, is permitted to be sold. C.J.B.

**501. Soft Curd Milk.** ANONYMOUS. Milk Dealer *27:* 9, pp. 62–66, June, 1938.

A review of the research work which has been done by the dairy schools on soft-curd milk. C.J.B.

**502. Homogenized Milk.** ANONYMOUS. Milk Dealer *27:* 9, pp. 37, 58, June, 1938.

Further reports on what dealers who distribute homogenized milk think of the product. These dealers report a steady increase in homogenized milk sales. Some of them also report increased sales of cream due to the sale of homogenized milk. C.J.B.

**503. Detecting Under Pasteurization by Means of the Phosphatase Test.** DR. T. H. BUTTERWORTH, Dept. of Health, San Antonio, Tex. Milk Dealer *27:* 9, pp. 33, 66–70, June, 1938.

A brief description of the phosphatase test and how it is of value to the milk-plant operator as well as to the control official. C.J.B.

**504. Da-Lite Dairy.** ANONYMOUS. Milk Dealer *27:* 8, pp. 46, 47, 67, May, 1938.

A brief description of the Holbrook Farms Dairy at Brentwood, Maryland. C.J.B.

**505. Efficiency and Sanitation.** ANONYMOUS. Milk Dealer *27:* 8, pp. 44, 45, 82, May, 1938.

A description of Moore Brothers' Dairy at Ames, Iowa. C.J.B.

**506. Homogenized Milk.** ANONYMOUS. Milk Dealer *27:* 8, pp. 38, 39, 69, May, 1938.

The usual response to a questionnaire sent to milk distributors from Virginia to the State of Washington, and from Canada to Tennessee, was to the effect that "once customers use homogenized milk they like it very much and don't change back to regular milk," or from month to month its popularity to date has been increased.

The type of outlet of homogenized milk and the reaction of individual distributors to the product are also given. C.J.B.

*Editor's Note:*—This article is based on the response of 15 milk distributors who have been distributing homogenized milk from 1 month to 10 years. These distributors were contacted by The Milk Dealer to learn the favor accorded this product.

Other abstracts of interest are: 474, 475, 476, 479, 480, 481, 482, 483, 485, 487, 488, 489, 507, 508, 509, 510, 511, 512, 513, 514 and 516.

## MISCELLANEOUS

**507. Minimum Wage Legislation.** BERNARD SUMMER, Ice Cream Trade J. *34:* 4, p. 24, April, 1938.

The author presents the fourth of a series of tables showing violations and penalties, by states, as outlined in the Minimum Wage Legislation. W.H.M.

**508. Showmanship in Business.** ZENN KAUFMAN. Ice Cream Field *32* (6): p. 23, June, 1938.

This is a concluding article of a series by the author. He states "Keep your advertising simple by emphasizing one basic appeal possessed by your product. You may want to stress purity, economy, flavor, healthfulness, or reputation. All these factors have their merits but when thrown on the public all in a heap their effectiveness is lost." W.C.C.

**509. Social Security.** J. S. SEIDMAN, C.P.A., Director, New York Chapter, National Association of Cost Accountants. *Milk Dealer 27:* 10, p. 60, July, 1938.

A brief discussion of the link between payroll taxes and income taxes formed by a recent decision which allows employers to deduct payroll taxes on their Federal income tax returns. C.J.B.

**510. Microbe "Death Ray" Lamp.** ANONYMOUS. Milk Dealer *27:* 10, pp. 36–37, July, 1938.

An ultra-violet lamp, developed by Drs. Rentschler and James, is reported to give 99.99 per cent sterilization in a few seconds time. C.J.B.

**511. A New Light Weight Stainless Steel.** ANONYMOUS. Milk Dealer *27:* 10, p. 33, July, 1938.

Ludlite, a new stainless steel, consists of a Silcrome stainless steel facing approximately 0.0095 inch thick, with a tough, waterproof, flexible backing of non-metallic material. The Silcrome stainless steel and the flexible backing are permanently combined under heat and pressure.

Ludlite has already been used as a building material in many ways. Its flexibility and relatively low cost opens almost unlimited possibilities for use in the bottled milk industry. C.J.B.

**512. A Cornhusker Sees European Dairying.** PROF. H. P. DAVIS, Dairy Husbandry Department, Univ. of Nebr. Milk Dealer *27:* 9, pp. 76–79, June, 1938.

The author describes the dairy industry of Europe. C.J.B.

**513. Highlights of the New Tax Law.** J. L. SEIDMAN, C.P.A., Director, New York Chapter, National Association of Cost Accountants. Milk Dealer *27:* 9, pp. 42, 66–67, June, 1938.

The author discusses the effect of the new tax law on corporations and individuals. Income tax rates, capital gains and losses, and other provisions of the new law are discussed. C.J.B.

**514. Some Practical Suggestions on Fighting Flies.** ANONYMOUS. Milk Dealer *27:* 8, pp. 74–76, May, 1938.

Practical method of preventing the access of flies into the milk plant and methods of disposing of those which get into the plant are given. C.J.B.

**515. Lanital, the New Textile Material Made from Casein.** ANONYMOUS. Milk Dealer *27:* 8, p. 72, May, 1938.

A brief description of the process and present status of obtaining a spinning fibre from casein. C.J.B.

**516. The Need for Scientific Cleaning and Sterilization of Dairy Equipment.** W. E. NOYES, The Diversey Corporation, Chicago, Ill. Milk Dealer *27:* 8, pp. 52–60, May, 1938.

The author gives a full discussion of the following points:

1. The fundamental factors to consider in analyzing the cleaning job.
2. The factors to consider in selecting a cleaning compound.

3. Properties which a cleaner for general use in the plant should have.
4. Points to check in the operation of the can washer.
5. Properties to consider in selecting a washing product to use in the bottle washer.
6. Properties to consider in selecting a sterilizer for use on the dairy farm and in the milk plant.
7. Methods of using chemical sterilizers. C.J.B.

**517. Preparation of Cultures.** JOSEPH BURNS, Mgr., Capitol Dairy, Madison, Wis. Milk Dealer *27:* 8, pp. 49, 78, May, 1938.

A description of the preparation and control of cultures. The author gives the following 4 laws of culture control:

1. Use good mother culture.
2. Sterilize all utensils and containers before and during process of manufacture.
3. Use clean base for medium. The skim or whole milk used must be fresh.
4. Have proper and uniform incubating temperature, together with correct length of time. C.J.B.

## PHYSIOLOGY

**518. Intervals in the Electrocardiograms of Calves Fed Cod Liver Oil.** LEROY L. BARNES, GEORGE K. DAVIS, AND C. M. MCCAY, Laboratory of Animal Nutrition, Cornell University, Ithaca, N. Y. Cornell Veterinarian *28:* p. 16, 1938.

The feeding of various levels of cod liver oil did not affect the intervals in the electrocardiograms of calves. There was a gradual increase in the intervals, most prominent in the P.R. intervals, as the animals grew older. Histological studies of the hearts revealed no lesions. J.F.

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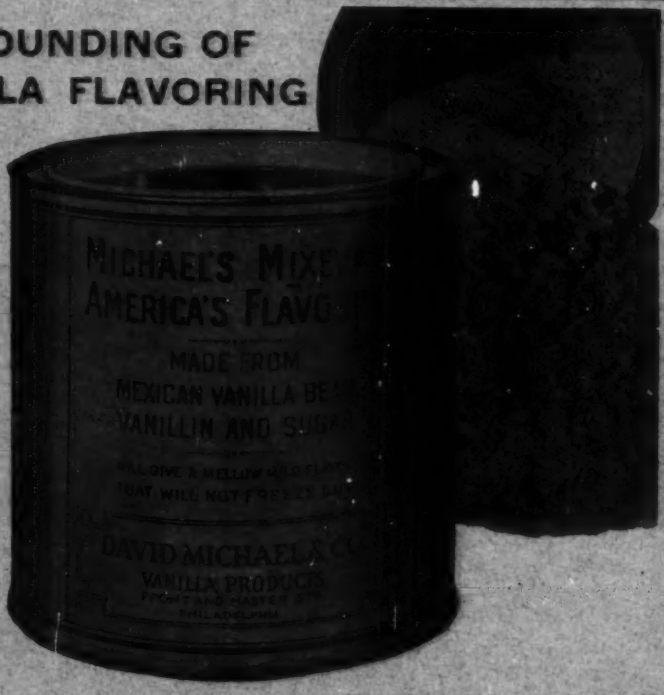
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